FEBRUARY 10, 1981

#### Hydrology

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TIME OF CHOCUMATERS! LIVAL RADIOTRACES DATING
S. S. Gupca, D. Lei and P. Sharas (Physical
Laboratory, Absendabed 180009, India) 5. B. Capca, D. Lei and P. Sharas (Physics)
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3130 Ground Water ANALYS 15 OF THE RECEPTROCITY CONCEPT IN POROUS

MEDIUM.

6. K. Faladn | Department of Petrolnum Engineering University of Ibedan, WIGKRIA)

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3150 Precipitation The Mainstorm which caused the Morvi day disaster

NEW PAIRSTORM WRICH CAUSED THE MURRY DAN DISASTER IN AUTUST 1979

O.S. Dear (Isian Institute of Tyopical
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lico Puroff and Streamfiou & LEART PRIERYOFR MODEL FOR EPHEMERAL FLOW RECESSION & Penhissioffire of Susface Minlug, Dept. of Interior, Marhimston, D.C., 20210; 2, 8, Smith and 8, 2, Yahrmeton

Interior, Marhipton, D.C., 202101 B. S. Saith and B. 2, Yakowite The flood was in sphemars streams can often be posteroyed scuretally by assuming "finitationance" rise to pak flood stage idepth) and specifying a secualize outree. Bere sevented for modeled as a conceptest analog of discharge from a single leaky searching.

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Mater Resour. Sec. Feper 601141 Water Resour. See. Paper 80W1741

3160 Summif and ntreamflow THE PREDICTION OF RIVER WATER TEMPERATURES

of ottakelyoe, 26 Richard Street, Olsagow (d. LD), Ur]
Temperature in arguably the most significent single determinant of metor quality but data ess collected at compassively few locations and ere rarely subjected to systematic analysis. This pape, details two different cathode suitable for vater managete esgaged is predicting river temperatures on an operational basis over a wide range of time scales. Firstly, simple liener range and time scales. Firstly, simple liener annual and monthly river temperatures to as seeptable lovel of accuracy oting air temperatures at one mapping and season of time temperature in order to espressed the observations of river temperature in order to espressed the observations size associal and diurcal cycles. (Prediction siver exter temperature)

DEFINAL SECRITION HTMRO DEREDULING FROM THE PERHEIPLE DF PROGRESSIVE OPTIMALITY Andro Turgeou (Hydro-Quabac, Verennes, Qua., Canade JOL-2FO)

This papes presents are algorithm based on the principle of progressive optimality for determining the optimal short-term scheduling of sulfinesservoir power spatemen; the meshed takes jobs accepted mater head weelstform, spilling, and cine delays between upstream and dompaces are readvoire. The stand is computentonally sificient and has mindad a torget readvances. minimal storage requirements. The convergence is consistent with the convergence is consistent to dynamic programming, the state variables do not have to be discretised with the method. An example commetcing of lost hydroplants for sensies is softed and the results are presented.

3170 Snow end lie AUTOMATED SYSTEM FOR COLLECTION SHOW AND RELATED SYDROLOGICAL DATA IS MOUNTAINS OF THE WESTERN UNITED STATES

SYROGOGICAL DATA IN HOUTTAINS OF THE VESTERM UNITED STATES

Sobel 5. Rallison (Englasering Division, Boil Conservation Service, PO Sor 2890, Wahlagton, DC 20013)

Conservation Service, PO Sor 2890, Wahlagton, DC 20013)

Conservation Service, PO Sor 2890, Wahlagton, DC 20013]

Convent runoff, primarily from mountaids, nonitributes about 735 of the value supply is the western thirted States. Snow and related hydrological data hase been nolicated from semoits mountain sites for arre than No years primarily librough annual methods. An automated data collection system called SNOTEL (for appearable to the system called SNOTEL (for appearable to 1975, and installation of the suries eyeben of the system passed an operational test carly in 1975, and installation of the suries eyeben of approximately 500 subcombed date mitted in 1975, and installation of the suries eyeben of approximately 500 subcombed date mitted in 28 proximately 500 subcombed date mitted in 28 proximately 500 subcombed date mitted in 28 proximately 500 subcombed date into its assessmental at man MOTEL site. The subcombed at examples at more than 500 or the 1600 date standard at man MOTEL site. The subcombed date in 1600 date sites in the sport date into the subcombed date in 1600 date station. The system which operation in maser real time, in may see the subcombed at the control of the solution and Iransmitting date from at hany as 1000 seents mitted at another sites and from an any as 16 digital or stables sensors attered at the control of the 501 proximal sites and from an any as 16 digital or stables sensors at any as 15 digital or stables sensors attered at the control of the 501 proximal sites.

# Modern Geodetic Earth Reference Models

Bernard H. Chovitz

Nationel Ocean Survey, NOAA

A geodetic earth reference model is defined as a selfgravitating body of given mass and rotational rete whose surface is an equipotential ellipsoid of revolution of specified dimensions. Over the course of this century, the international Association of Geodesy has sanctioned three such models as recommended standards for both scientific and practical applications. The most recent model was approved in December 1979, replacing one chosen in 1967, which in turn supplented another originally adopted four decades asriler.

#### Introduction

One of the chief scientific aims of geodesy is the determination of the size and ahspe of the earth. Therefore, much of the energy expended by geodeelats has focused on finding a modal (defined by both geometrical and physics) parameters) that can serve as e aultable reference surface for further geodatic and geophysical investigations. 'Suitable' is a flexible term. In the 19th century, It may have infarred accuracy to one part in 104. Nowadays, it signifies better than one part

Another equally important elm of geodeay is to provide a rigorous and precise basis for aurveying and mapping. An Internationally accepted reference model expedites cooperalion between countries and serves as a secure foundation on which to aupport expensive and time-consuming projects. Toward this aim, permanence, or at least longevity, le as vital as accuracy.

The purpose of this article is to cover the development of recognized models for the tigure of the earth during this cenlury. The determinations of the earth's scale, by Eratosthense in the 3rd century B.C., and of its flattening, by the Paru-Lapland expeditiona in the 18th century, are well known to most scientiats. But the remarkable improvements occurring in recent times are not generally appreciated outside of the narrow geodetic community.

By recognized models' we mean those that have received a measure of official approval by the international Association of Geodeay (IAG) and its covering organization, the international Union of Geodesy and Geophysics (IUGG). Thue this narrative, in large part, ia a history of delibarations of the IAG. Much of the Interest centers on the reaction of the IAG to the conflicting requirementa induced by the two aims mentioned above.

#### The Normal Ellipsoid

The prototype model for the tigure of the earth is a blaxial ellipsoid of ravolution which is completely spacified by two geometric parameters. Let a and b ba the earnimator and semiminor axes of this model. The flattening f is defined by f = (e - b)/a. Customarily and conventionally, a and f are the two paremeters daalgnated. If gaometric quantities, like arc measurements and relativa station positions, are all with which one is concerned, then such a model is adequate. Howaver, once physical properties are considered, a less elmple approach must be taken. For the computation of grev-Ity on the modal, it is obvious that one has to introduce some information on the maae of the earth, that ia, a third paramalar. Furtharmore, it is also obvioue that this value of gravity is



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Cover, 6 mail: Impaci crater near Taal volgano. Crater is only 0.9 m In diameter, and it shows the shook weves left by the impact of a bomb lossed out of the crater in the 1985 emption. (Photo courtesy of Francia J. Heyden, Manila Observatory, The Philippines.) influenced by the fact that the earth is rotating, indicating the naed for a fourth parsmater. But Ihls euffices. Earth models are now usually defined by four parameters (plus a designstion of the orientation of the axia of maximum inertie in inertial

Thus it can be inferred that e legitimate model, which ahould be abls to handla both physical and geometric chores. might be an allipsoid of revolution of mass M, rotating st anguisr speed  $\omega$ , and hance defined by a parameter tamily (e, f,  $\overline{M}$ ,  $\omega$ ). It is shown in alandard texts [a.g., Heiskanen and Moritz, 1967, pp. 64-67] that if the constraint is imposed that the surface of the model be lavet (i.s., equipotential), then the exterior gravitational field ganarated by this configuration is uniqua (Tha so-called Somigliana fiald). Nota That no asaumption has been made about the distribution of mass within the model. This model is designated as a normal ellipsoid.

The accuracy of the model depends on how wall the numerical values of the parameters are chosen. In order to accord with reality, they should be based on the beat observetional data available: a has slways been comparatively well determined from arcs of irrangulation,  $\omega$  depends on straightforward sstronomical measurements, however, in two inatancea, M and f, the observational material is reistively waak. Fortunately, these particular parameters can be replaced by equivalant quantiliae I hat are much better determined. Consider the product GM, where G is the universal constant of gravitation. One need be lamiliar only with Newton's law of gravitation to realize that in deeling with any messurement involving the earth's gravity field (and thus bringing into play physical considerations), whenever M appears, it is In the guise of GM. Modern measurement techniques which employ artificial setellitea and planetary probes have refined The value of GM to 1 part in 107, whereas M itself is known only to about t part in 103. Prior to the artificial satellite era. the best determined quantity releting to the earth's gravity field was auriace gravity itsalf. It was thus customary to accept as a parameter in piece of M The equatoriel valua of gravity  $y_a$ , whose unique relation to the other paremeters is spelled out in Halskanen and Moritz (1967, p. 89).

Historically, a variety of geometric and physical methods have bean employed to datermine /. A complete record can be found in the monograph by Strasser [1957]. However, up until 1957, when the first artilicial Earth salellite was launched, eccurecy was good only to herdly better I han 1 part in 100. (Strasser's account goes through 1953.) Then, almost immediately, an equivalent parameter was delermined from observations on artificial salelilles to et least an order of magnitude bettar. This paramater, the dynamical form factor, dasignated by  $J_2$  (because if let he coefficient of the second zonal harmonic term in the spherical harmonic expansion of the earth's exterior potential field), is directly related to f for a normal allipsold by a closad formula involving just the other independent parameters (Heiskanen and Moritz, 1967, p. 73]. Thus the modern definition of the normel allipsoid is by maans of the parameters s, J., GM, w.

We strese again that a perticular normal allipsoid generatas a unique exterior gravitational field. This field can be specified by an infinite set of coafficients J, (l = 2, 4, 6, ...)that correspond to the avan zonal harmonic terms in the apherical harmonic expansion of the aerth's potential. Howavar, all  $J_i$  for i > 2 are functions of the parameter sat (a,  $J_2$ ) GM, ω). It is interesting to consider the renge of parameter seta that can simulate closely the actuel gravitational flaid. For example, one can take the real value of  $J_a$  but set  $\omega = 0$ . in that case, f would be about 1/700, lass then half fhe real value. But although  $J_2$  is anforced to be the same, the other  $J_\ell$  will change, and thus the property of uniqueness is honored

Because the polantial is constant on the auriace of the normal ellipsoid, ite value  $U_0$  (units:  $m^2e^{-2}$ ) could replace a as one of the defining parameters. This has a certain appeal, eince the set  $(U_0, J_2, GM, \omega)$  relates directly to the physical eltuation (cl. also Bulletin Géodésique, New Series 118, 1975, p. 402). However, Up sulfars from the aama observational deficiency as M; a is much more accurately measured.

Recapitulating, the modam accepted model for the figure of the earth is the normal allipsoid, delined thus: (1) its geometric shape is that of an allipsoid of revolution with semimajor axis a and flattening f. (2) The mass of the alfipsoid is M. (3) The ellipsoid rotates at angular speed ω. (4) The aurface Islevel.

Undar thas a assumptions the exterior gravitationel field le completely determined, although the interior field is not. Howaver, the choice of the four defining parameters constrains the possible distribution of mase within the model. For example, if the additional assumption were made that the mods in fluid equilibrium, than this would force the density to be homogeneous. If we wish to retain on Earthilke density distribution elong with conditions (2), (3), and (4), then (1) becomes diatorted into a fourth-order auriace that requires an additional parameter for complete delineation. For a more penatrating discussion of this topic, see Moritz [1968].

#### The international Ellipsoid

Specifications for a unified model (like the normal ellipsoid) that is cultable for both geometric and physical applications were not formulated until this century was wall underway. However, the requisife theory had been available in Friedrich Helmert a monumental treatiee [Halmert, 1880]. At the beginning of this century, there was much activity to delarmine geometric ellipsoids that would serve as reference figures for large thangulation systems end to set up standard gravity formulas that were darived from a simple mase configuration from which gravity anomelies could be computed. Measured values of gravity itself served as a basis (and, according to Helmert, the best baals) for datermining the geometric fialtening, the link being through the cleselc (18th century) formula of Clairaut. The name of Halmart pervades all research In this field during this period. In 1901, he published a value for f, 1/298,3, which was based on gravity measuremente. Five years later, he computed a to be 6,378,140 m, based on European arc measurements and the aforementionad value of f. The closeness of this set to presently accepted values is

almost uncanny. An alement of luck is suraly present here, because, upon adding more data, Halmart's values of a fin a eubssquent solution incressad to 8,378,200 m.

Also, at the beginning of this century, a large affort was mounted at the U.S. Coast and Geodelic Survey, under the leadership of John Hayford, to determine a reterence ellipaold by applying a principle heretofore untried for this purpose. The method employed by Helman was to minimize (in the sense of least squares) the observed deviations of the actual Earth from an silipsoid of ravolution by Ireating theee deviations ae random. Hayford reelized that the observations could be blased because of their poor distribution end refative paucity. He therefore applied the theory of isostesy as a corrective procese to hie observationa, all in the U.S. A pre-Ilminary adjution was announced by Haylord at the 1908 General Conterence of the International Geodetic Associatlan (the progenitor of the International Association of Geodasy), and a reviaed actution, based on additional date in the U.S., was presented at the next general conference, held in 1909. This is at solution consisted of a = 6.378.388 m and t =1/297.0. The time was ripe for official international agreement on a alandard model to which geodetic triangulation, now overrunning national boundaries, could be referred. World War I interrupted auch considerationa. Howaver, the queellon was raised at the constitutive as-

sembly of the fUGG in Brussels in 1919, and was formally discussed at the first general essembly of the IUGG, hald for Rome in 1922. At the meeting of the then-termed Section of Geodesy (The title of Association came into effect in 1932 and of International Association in 1946). William Bowle brought up the distinction between the scientilic and the practicet purposee for a choice. Tha former required the best (i.e., the most accurate) determination, whereas the latter simply demanded unsnimity among the national geodetic organizations. A resolution paased by the assembly in Romo advocated (modestly) a common reterence ellipsoid for all nations on the same continent. The next general assembly was held in Madrid in 1924. Just before the assembly convened, the executive committee of the Section of Geode sy agreed that the Rome resolution be modified to consider e eingle ellipsoid for ell continents. A great deal of spirited discussion ensued during the general sassions. Atthough leeling was practically unenimous on the need for an international reference ellipsoid, the choice of parameters was controversial. In particular, the British delegation lavored a rounded set of values (i.e., the semimajor axis specified to only live significant figures). Because Haylord's value of f matched fairly closaly (l.e., to within the stelad standard arrors) the result obtained from Helmert's gravity investigations, and because it gave the impression of being a rounded value (1/297.0), there was little opposition to it. On the other hand, the choice of e was bitlerly contested. Hayford's result was criticized bacause it was besed solaly on maasuraments in the U.S. and because Ils seven significant figuras were too many to ba beliavable. Bowla defanded the Hayford value by erguing that the application of the theory of isosiasy and the varying terrein in the U.S. sufficiently generalized the solution. Moreover, he was against rounding, because the exact result made it clear on what basis the values were chosen and to what the standard errors raferred. Heyford's value of 6,378,386 m was narrowly approved by a vote of 19 to 17.

Thus, for the first lima, a reference ellipsoid was officially recognized by the international geodetic community. It was termed the International allipsoid. There are two interesting footnotes ragarding this choice. First, although the geodesists walled until 1924 to take organized action, at a meeting of the international Congress of Astronomical Ephemeridee. In Parla in 1911, the dalegelea gave an official astronomical imprimatur to 1/297.0, an anticipatory action that was repeated, vis-a-vis the geodealete, in latar years. Second, eithough an American rasuli wae apotheosized internationally, the U.S. had no intention (and Bowie announced this in advance) of converting its own national triangulation eystem to the newly crowned reference modal because it did not daem that required effort as necassary or worthwhile.

Soon after the choica of thia set of geometric parameters, Lambert [1928] reised the queation of the dasfrability of detarmining a formula for theoretical grevity that was compatible with the internetional ellipsoid as a level surface. Casainis [1930] published the definitive formulas, besed on the work of Pizzetti and Somigliane (Heiskanen and Moritz, 1967, p. 70], and proposed the numarical values

> $\omega = 0.7292115(10^{-4}) \text{ rad a}^{-1}$  $\gamma_e = 978.049 \,\text{Gaf} (t \,\text{Gel} = 10^{-2} \,\text{ms}^{-2})$

Thase, combined with the internetional ellipsoid vetues of a and f, formed the basia for delining the infernetional gravity formula, adopted at the 4th General Assembly of the IUGG in Stockholm in 1930. A complete eet of paramaters for an internationally recognized normal ellipsoid had now bean estab-

#### The Geodetic Reference System 1967

After this, the question of revision of these parameters lay dormant within the geodatic establishment for 30 years. This was not due to lack of adjentific progress in improving their values. Hayford's semimejor axie was ganarally recognized to be loo farge. By omitting doubtful observational material.

#### **Housing Accommodation Corrections**

Please note the following corrections regarding hotel accommodations at the AGU Spring Meeting: After confirmation has been received, changes and cancallations should be made with the hotel directly. Prior to confirmation, questions about your notel eccommodetions should be made in writing to Housing Coordinator, AGU Spring Meeting, Baltimore Housing Bureau, 1 West Pratt St., Baltimore, Md. 21202, See paga 38, January 27 laste of Eos for forma.

the Coast and Geodetic Survey's refinement of Hayford's computations indicated a decrease line of about 150 m [Schmid, 1953]. Independent determinations by Krasovsky in 1940 [Sirasser, 1957, p. 74] and Chovitz and Fischer [1956], which used nawly aveilable long arcs, confirmed tha elephaniic size of the officielty edopted value. However, two reasons lay behind e lack of interest in change. The first, held by the 'practical' geodesists, was that the purpose of the normal ollipsoid was to serve as a fixed reference. The deviation of the reference from reality was not crucial, but its meaningfulnoss os a reference would be dissipated if it were frequantly slisred. As one well-known geodesisi excisimad in e discuselon on this subject during this period, 'A cubs could serve the purpose edaquately. This point of view, estletaclory as it may have been to those in charge of preparing ristional geodetic networks and cartogrephical products, offanded 'eesthelic' geodesists. However, the fatter were held back by the second reason, which was the wide discrepency in accure cy of determinetion emong the peremetere. A revision in e, based on letest knowledge, would have reduced its error from 4 to 2 parts in 105. But there was not much point in attending to this while en error of almost 1 pert in 102 remained in /. As mentioned earlier, observations on artificief Earth satsi-

fitss, beginning in 1957, provided e breakthrough—indeed, ths most spectacular, pertieps even the most significant, in the history of geodesy. An analysis of these developments is not within the scope of this stricte, which is intended to present en overvisw of the history of the adoption of official refersnce models. We simply mention that after the first order-ofmagnitude jump in eccuracy of f through its surrogats  $J_2$ , e eleady cumulative improvement continued to flow in for J and GM from a variety of spece-beard observations. Just as important a loctor in opening up the question of improved relerance modals was a psychological shift in geodelic viewpoints around this time. An initux of people who were trained primarily in other fields like astronomy and engineering initiaenced the classical geodelic outlook. In retrospect, it is not surprising titel the astronomars look the lirst concrats official sisp toward rovising the international allipsoid, since they wers unaffected by the burden of recalculating Irlangulation points or map corners. The International Astronomical Union (IAU), organized the

lem—thet of reviewing and lormalizing a system of astronomical constants. The four parameters that defined the normal ellipsoid occupied the IAU only peripherelly. However, once it was decided to considor ravisions. It was logical to examine crilically all the constants in current usege. In perticular, the informational ellipsoid values of e end I, and the infernational growly formula of 1930 were part of this system. In May t 963, the fAU organized a special symposium in Paris on the system of astronomical constants. It was agreed their a working group would be formed to prepare recommendations to be presented formally to the noxt (AU General Assembly, which would lake place the following year. But before then, end just after the Peris symposium, the IAG held lis (3th Gensrsi Assembly in Berkeley. The Perismeeling was duly noted, and e small committee was formed to serve as lisison with the IAU 'to make known the point of view of the IAG' (Bullstin Geodesique, New Series 70, 1983, p. 304). But the conservative bent of the IAG was evidenced by the psesege of e resolution thet 'no change should be made at the present time in the international gravity formula (Builetin

same year as the IUGG, in 1919, faced a much broader prob-

Geodesique, ibid, p. 408). At the fAU General Assemblyin Hamburg in 1964, the following parameters were edopted: e = 8.378,160 m;  $J_2 =$ 0.00 t0827; and GM = 398,803( $t0^9$ ) m<sup>3</sup>/s<sup>2</sup>. From other primary astronomic constants, one can derive [Bulletin Géodésique, 1970  $\omega = 7.292 t t5 1467 (10^{-5}) \text{ red e}^{-1}$ . The corresponding value of / Is 1/298.25.

Although no uncertainties were listed, the IAU working group that made the recommendations stelled that the true values of the primary constants are believed to be between the following limits: e-6.378,080 to 6.378,240 m;  $J_2-$ 0.0010824 to 0.0010829; end GM-398,800 to 398,608(109) m³/e².' (Bulletin Géodéeique, New Series 75, 1965, p. 63). The values of  $J_2$  and GM were based on spece observations, while that of e depended primarily on the recent geodelic arc msasurements. (For example, the solution of Chovitz and Fischer [1956] yielded e velue of 8,378,135  $\pm$  30 m lf f were

The IAG was thus presented with e fell accompli when its 14th General Assembly met in 1987 in Lucerne. There was still en attitude of ambivelsnce, as shown by thie pessege (freely translated from the French) from the report of J.-J. Levaliois, the IAG Secretery General:

The Association cannol indefinitely give the imprethat it has no interest in this question and let other organizations make the decisions which ereincumbent on it, sven if—as it sppears to be the cese—the problem does not eppeer to be of fundamental importance to its proper work. (Builetin Géodésique, New Series 88,

The IAG proceeded to pass e resolution, confirmed by the IUGG, that set up a Geodetic Reforence System 1967 to supplant the 1924- I 930 international model. The perameters selected were identical to the ones chosen by the IAU. In order to stress that the IAG had not been left completely in the lurch, the resolution contained the somewhal plaintive phrese, 'considering . . . that the IAU in consultation with the JUGG has adopted . . . ' (Bulletin Geoglesique, lbld., p. 367; italics edded for emphasie). The bald fact was that the IAU had taken the lead in a matter which treditionally wes the responsibility of the IAG.

In a manner of making amends, the IAG authorized and carried out a definitive development of derived constants end lables for the normal ellipsoid. These were published in a special issue of the Bulletin Geodésique [1970], and they contained e new standard gravity formule to replace that of 1930. The change in the value of y, (cd., table of official val-

ues of parameters) was due largely to an updating of the reference origin for absolute grevity. In eddition, e datailed analyele of the effect of the etmosphere was made. The stmoephare has discemble mass, which ertificiel satellites 'consider' to be part of M. On the other hand, it is exterior to the surface. The problem is resolved by condensing the mass onto the surface. For points incide the atmosphere (as opposed to points outside, like artificial satalities), a correc-Ilon table was prepared to be added to measured gravity. The correction varies from 0.87 mGal at the surface to 0.01 mGsl at 32-km hsight.

#### The Geodetic Reference System 1980

Even et the tims of the 1987 General Assembly, sufficient new data had been emassed that it was recognized that the 1987 paramsisre could be sire ady improved. For sxempls, Veis [1988] publisheds = 6,378,142 m, GM = $3.986009(10^{14}) \text{ m}^3\text{s}^{-2}$ , end  $J_2 = 108,263.9(10^{-8})$ , based on a combination of the latest space and terrestrial observations. But the only ection taken in this respect at the 15th General Assembly of the IAG and IUGG in Moscow in 1971 was to confirm the 1987 normal silipsoid by sdopting the spacial publication of the Bulletin Géodéalque [1970] as the official statement of the IAG about a reference model. However, the IAG initiated a more positive stilltude then in the previous decade. Perhaps it had the premonition that the IAU would revise its 1964 sat of ssironomical constents at its general assembly to be held in 1976. At a meeting of the IAG Executive Committee in February 1974, s speciel study group of the IAG was suthorized. Their chargs was to advise the IAG on the most up-to-data values of 'fundamental geodelic constants, of which the four paremeters of the normal ellipsoid constituted a subsat.

Accelerated activity by the IAG, sterting in 1974 and culminetling eventually in the replacement of the 1987 reference system, was mainly due to the work of this study group, end In particular to the anargetic leadership of its president, Helmul Moritz.

For the 16th General Assembly of the IAG et Grenoble in 1975, the atudy group recommended the following values as 'currently representative eatimstes':  $e = 8,378,140 \pm 5m$ ;  $J_2 = 108,263 \pm 1(10^{-8}); GM = 3,986,005 \pm 3 (10^{6}) \text{ m}^3\text{s}^{-2}; \omega$ = 7,292,115(10-11) rad s-1.

The change from the  $\pm 967$  salls not trivisi. Both  $J_2$  and  $\pm GM$ sre given to one higher order of magnitude, and s is sitered by 1 partin 300,000. The reasons for rounding ω down from 1t to 7 significant digits wers, first, baceuse varietions of the ennuel mean value of  $\omega$  could affect the eighth figure, end, second, seven digits correspond to the eccurecy of the other

This set was presented as pertof e more comprehensive collection of constants, including values of other spherical hermonic coefficients of the eerth's potential field. Thus the overall group of constants does not define a normal ellipsoid. This was not the intent of the study group, since in its report (Bulletin Geodésique, New Saries 118, 1975, p. 405) It advocated that the Gsodstic Reference System 1987 remain ths eystem officially recommended by the IAG, because too frequent a change is not edvisable.' The IAG took this edvice by epproving, et Grenoble, e resolution that listed the values given by the etudy group 'ee currently representetive estimstee' but elso eteting thet 'this resolution does not effect the velidity of the Geodelic Reference System 1987 for raisrance purposes. Agein, the conflict between the two purposes of en official reference eystem was manifested. A lerge segment of the delegates at the assembly took the point of view that e reference eystem loses its euthority end cannot be teken seriouely if it is frequently changed. (Perhaps there is a vague enalogy with modern eulomobiles whose models are changed snnually). On the other hand, the ergument that change was costly to those in charge of leauling geodetically rsleted products did not cerry as much weight as before because of the evailebility of high-speed computers for effecting numerical transformetions. Nevertheless, the IAG had postponed eny official revision of its 1967 reference system until

The IAU did not lebor under eny such compunctions. At its 1978 General Assembly, elso in Grenoble, it sdopted es part of its letest set of eetronomical constants the same values for  $\theta$ ,  $J_2$ , end GM as had been recommended by the IAG atudy group and scknowledged by the IAG the yeer before.

The questions to be considered and resolved by the IAG at its next general asesmbly, et Cenbarre in 1979, were: firet, ehould the 1987 reference eyetem be changed, and second, If so, should the IAG egain follow in the footstaps of the IAU or eirike out boldly on its own. The specific recommendations In this metter egain devolved on Moritz's atudy group, the tenure of which had been extended eembly. It is intriguing that attitudes and ections peralleled very closely whet hed occurred et the 2nd Ganeral Assembly in Medrid 55 years before. Concerning the first question, s strong majority of the study group members advocated that a new official reference system be adopted. The eacond question wee not se eeeily resolved. The study group revised the 1976 'currently representative estimates' as follows: e = 8,378,137 ± 2 m;  $J_2 = 108,263 \pm 1(10^{-8})$ ;  $GM = 3,988,005 \pm 0.5(10^{-8})$  m<sup>3</sup>8 - 2;  $\omega = 7,292,115(10^{-11})$  rad s<sup>-1</sup>. Of these, GM,  $J_2$ , and  $\omega$  were not controvereigl; no recent evidence (except for additionet data confirming the value of GM) hed lurned up to refine the values named by the study group in 1975 end subsequently edopted by the IAU. But e great deal of new evidence hed eccumuleted fore, especially from the altimeter data ecquired from the GEOS 3 selelitie. The value 8,378,140 m implied an accuracy to alx algoriticant ligures, whereae it was now believed that the uncerteinty fne hed been reduced to 2 or 3 m et the moet. The islest solutions pointed to 6,378,137 m as the most likely value if a lieting to seven figures was to be given. The ergument egainst this was that future refinements could very well converge on 138 or 138, and so seven figures should not be listed until one is sure of the seventh figure. The proponents of seven figures believed if was better and more eccurate to be in error possibly by a meter or two than to neglect entirely the infor-

# **Forum**

#### **GIFT**

Something that has not been manilloned yet in the appeal for gifts to AGU is the possibility of funding a scholarship that would be administered by the AGU. To keep geophys. ics an silve and vital discipline, we must continue to sitract the bast young minds to the field. If we established a wellendowed fund with sufficient resources to more than sdequatsly fund a graduete student through 2 or possibly 3 years of greduate work, the ettendent publicity and netionwide stisntion could do much to attract these good young minds to our field.

in your talks with potential donors I urge you to keep the possibility of echoisrship endowmants in mind.

> C. T. Russell, Chairman AGU Committee on Education and Human Resources

Whenever potential uses of an endowment fund have been discussed, the needs for scholarship espistance have been emphasized and given high priority. This point should heve been included in the initial brochurs, 'AGU-Girding For Tomorrow,' of the appeal. We will have other opportunitlea to restete the goels. A 5-year effort has many win-

Through the fine work of your committee and others, the Union has underlaken e modest echolarship program. The support for this progrem has been charged to 'operational' funds and not drawn from the income of the existing andowment fund. The 1981 budget adopted by the Council of its December meeting in San Francisco includes grants for the continuing program to ancourage students from minority groups to enter geophysics (see Eos, March 11, 1980) and for the Congressional Science Fellow Progrem. There is a scholarship for a woman in the atmospheric sciences funded through gifts from June Becon-Bercy. Also, the income from the Berkner Fund, which is being treated as an andowment fund, is being used to pey duss for an initial 3ysar period for young geophysicists who live in developing countries. We balleve that about 50 euch grants can be mede esch ysar.

I recognize that these examples ere mera tokens of the type of scholsrship program that might be developed under a well-supported endowment fund. I hops that other mambers of AGU are as concerned as you. There are opportunities for donors and groups of donors to identify their gitts as a scholarship fund in memory of a colleagus or format professor. These are decisions for the donore.

> Cheries A. Whitten Earl G. Droessler Cocheirmen, GIFT Steering Committee

metion provided by the seventh figura. Competibility with that IAU was not a concern because the slightness of the change would heve ineignificent effect on the system of entronomical conetants (P. K. Ssidelman, privete communication to H. Moritz, 1978).

At the 17th General Assembly of the IAG, at Cenberra in December 1979, en entira helf-dey was davoted to a presentetion end discussion of the proposed reference eyetem. The 'bold' epproach triumphed by a larger mergin then the correspondingly bold ection teken by the Sa cond Assembly at Madrid in 1924. (Since the number of delegetss was much greater, en scluei vots count et Cenberre wee neither feaelble nor needed, majority santiment being readily evident.) Thereby, the IAG forwerded to the IUGG the following resolution, which was approved and published as IUGG Resolution

IUGG recognizing that the Geodetic Reference Systern 1987 sdopted at the XIV General Assembly of IUGG, Lucerne, 1987 no longer represented the eize, shape and gravity field of the Earth to an accuracy adsquete for meny geodetic, geophysical, estronomical and hydrographic epplicatione and

Considering that more appropriate values ere now

#### Recommends

thet the Geodetic Reference System 1987 be repleced by a new Geodetic Raference System 1980, elso beead on the theory of the geocentric equipotential ellipsold, conventionel constants defined by the following equatoris! radius of the Earth:

e = 8,378,137 m

geocentric gravitational conetant of the Earth (including the etmosphers)

 $G\dot{M} = 3,988,005 \times 10^8 \,\mathrm{m}^3\mathrm{s}^{-2}$ 

#### Size end Uncertainty of Perameters

Parameter, units	Order of Magnitude	Uncertainty, ca. 1800	Uncertainty, 1980	
	8 (10 <sup>8</sup> ) 1/300 10 <sup>-3</sup>	1/2 (10 <sup>4</sup> ) 1/10 <sup>2</sup> 1/10 <sup>2</sup>	1/3 (10 <sup>8</sup> ) 1/10 <sup>6</sup> 1/10 <sup>8</sup>	
GM, m <sup>3</sup> g-2 γ, m s <sup>-2</sup> ω, s <sup>-1</sup>	4 (10 <sup>14</sup> ) 10 <sup>1</sup> 7 (10 <sup>-8</sup> )	1/10 <sup>4</sup> 1/2 (10 <sup>4</sup> ) 1/3 (10 <sup>7</sup> )	1/10 <sup>7</sup> 1/2 (10 <sup>9</sup> ) 1/3 (10 <sup>9</sup> )	

estimete of deviction from constancy rather than of

#### Officiel Values of Parameters

Systam	e, m	1	J <sub>2</sub>	GM, m <sup>3</sup> s-2			
1924-30 8,378,388	1/297.0	0.0010920*		y <sub>e'</sub> m s <sup>-2</sup>	ω, red e <sup>-1</sup>		
1987	8,378,180	1/298.247*	0.0010827	3.88833 (10 <sup>14</sup> )* 3.98803 (10 <sup>14</sup> )	9.780480	7.282115 (10 <sup>-5</sup> )	
1980	6,378,137	1/298.257*	0.00108263	3.888005 (1014)	8.780318* 8.780327*	7.2821151487 (10 <sup>-6</sup> ) 7.282115 (10 <sup>-6</sup> )	

'Computed from the other parameters

dynamical form fector of the Eerth, excluding the permenent tidel deformation:

 $J_2 = 108,263 \times 10^{-8}$ 

anguler valocity of the Earth:

 $\omega = 7,292,115 \times 10^{-11} \, \text{red s}^{-1}$ 

(b) thei the seme computetional formulas, adopted at ths XV General Assembly of IUGG in Moscow 1971 and published by IAG, be used as for the Geodetic Referance System 1987, end

(c) that the minor axis of the reference ellipsoid, defined ebove, be perallel to the direction defined by the Conventional International Origin, and that the primary meridien be parallel to the zero meridien of the Bureeu International de l'Heure adopted longitudes.

The phrase 'excluding the permenent tidel deformation' is intended to emphesize that the normal value of  $J_2$  should be due entirely to self grevitetion end exclude the effect of the sun end moon. Peragreph (c) precisely orients the normal allipsoid in inartial space. This is vitel because, for geodetic reference purposes, orienistion is just as cruciei as scale.

The IAG Executive Committee authorized the speciel sludy group to continue to monitor the state of the ert in geodelicconstents end to report et the next (1983) IUGG Generel Assembly. However, eny recommendation et thet time to

change the Gaodetic Reference System 1980 is hardly concsivable. It is a fair guess that this letes! model mey see ue through this century.

#### Acknowledgment

Much of the information in this article was culled from verious leelles of the Bulletin Géodésique, going back to its inception in 1922. I hope it will not be considered presumptuous of me to dedicate this erticle to the memories of Georges Perrier, founder and aditor of the Bulletin Geodésique between the two World Wars, and Pierre Tardi, editor from 1948 to 1951, and to their euccessors: Jean-Jacque's Levelicle, editor from 1952 to 1864, Michel Louia, editor from 1885 to 1975, and Iven Mueller, the present editor. Ol course, any errore in this narretive are solely my responsibility.

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Bernard H. Chovitz is director of the Geodetic Research and Development Leboratory in the Notional Ocaan Survey of NOAA. His oducellonal beckground includes degrees in malhemetics from the College of William and Mary and Hervard University. He has been working in the field of goodeey since 1948 when he joined the Army Me p Sorvica etter o atini in the Navy during World Wer II. Hie principal intercete in geodesy have been directed to theoretical espects ond to applications of setellites. He is a past president of the Section on Space Techniques of the International Association of Geodesy (IAG) and remoins a momber of the IAG Executive Committee. Ho hes been actively involved in the Amorican Geophysical Union, hoving coedited one of the monograph series, served as on essociate ditor of the Rod JGR, end rocently completed a tarm as prosident of

## News

#### **Big Science Victim of Budget Game**

In an apperent affort to make certain that the newly proposed cuts in the federel budget reach all fections, except of course those that involve the military-industrial complex. David Slockman, the key pleyer of the 'budget game,' has isaked to the press soms of hie plans that could virtuelly sliminsts meny perts of big science over the next decede. Two sgandes that are important in this respect, and importent to a large proportion of the geophysical community, are NASA and NOAA. There are portions of the budgets of both of these egancles that because of military significance will go unscathed. Unfortunetely the 'scrose-the-board' cuts proposed by OMB Diractor Stockmen will heve to be concantrated on the rest that ere reletively indefensible from e military standpoint and that turn out to be the most science

fn en eccount epparently lesked to the Chicego Sun-Times and reported by that newspaper on Feb. 4, 1981. Stockman, one of the inventors of the term 'sconomic Dunkirk, is said to heve placed the science-oriented segmente

of the federal government on e 'hit list.' The projected cut to the NASA budget recently proposed

by the Certer administration is stated to be on the order of \$630 million, smounting to elmoet 10%. It is true that the fiscal year 1982 budget requeet for NASA exceeded the fiscal year 1981 actual budget by upwards of 22%. The problem is that aside from infletionery increases, including supplamentary ealary rates that are beyond the control of the agancy, the major portion of the increase is in space treneportation, i.e., shuttle! Possibly abuttle itself may be curislied in its leter miseione, but right now there is e greet

push, and there are extra coste to get shuttle off the ground. The proposed budget cuts for NASA fit the overall effort of the new administration to place intense pressure upon the federal government. In this context, and in the context of a numerical 'budgst game,' the cuts appear resconeble and perheps, logical. If these cuts are indeed made, their Implementation will be less than logical. NASA would have to curtail lie apacs sciencs program by more than one third. In doing this, all new missions would have to be cancelled, and in essence there would be no effective space science gram st alf. The two new missions, Gallieo and VOIR, would be scrapped. So would the Gamms Rsy Observetory, the Upper Atmosphers Exploration Progrem—possibly the Space Telsscope, and many others. One sees the perspective in realizing that if epproved, the Stockmen plan Would virtuelly put the Jet Propuleion Laboratory et Cel-Tech out of businese, and allminete it as the world center of space reeeerch within the next few years.

The cuts to other egencies, for exemple, NOAA and the U.S. Geological Survey, heve not been eo epecificelly fergeled at this time. Nonethelese, NOAA hae been told thet it can expect major cuts in its NOS satellite program end in the sea grant program. The NOS eatellite program, which is funded et a level of several fene of millions of dollers, le to be sliminsted entirely. The cut proposed for the see grant program is sletted et over \$21 million, which would mean e

reduction of the program by one helf in 2 yeers. Some Washington anelysis view the Stockman 'hit llet' as e series of 'trial balloons' Greet resistance and outcry from the communities end sectors to be violimized possibly could reduce or, in some casee, even eliminate specific cuts. Because the budget hee already been proposed to Congless by the outgoing administration, it is aniicipated that many of the budget cuts proposed by the new edminis-Iration may not be approved by the Senete end by the house. The congressional committees and eubcommittees that handle these leades will be sensitive, hopefully, to the culcies of the netion -- PMB 88

#### 'Wind Farm' Producing Electric Power

The nation's first 'wind larm,' tealuring three of the largest savanced wind turbine systems, is nasring completion. The turbines are the seventh, eighth, and ninth wind turbinss to be built under a portion of the tederal wind energy program. The tirst of the three new machines began producing slectricity for the Sonnsville Power Administration at Goodnoe Hills, near Goldendale, Wash., late last year. The second mechine will be fully assembled and bagin to generats slectricity in Februsry. The third machine is expected to be fully assembled and running late this spring

The three mechines, each rated at 2500 kW, will be tha first cluster of these experimental wind turbine systems. The new machines heve been designed to bring the cost of wind-generated electricity very close to the cost of power generated through the burning of fossil fuels.

When ell three are operating, by mid-t981, they will feed 7500 kW of eisciricity into the Bonneville power grtd, enough to supply 2000 to 3000 sverege homes. Designated Mod-2, the machines are the largest and most powerful wind turbinse ever built. The three Goldendele wind turbines, deelgned to heve a system life of 30 years, were built by the Boeing Engineering and Construction Co. of Seettle, Wseh., under contract to NASA-Lewie. Under eerlier Department of Energy lunded projects, sterted in 1974, NASA-Lewis built six smeller developments units, renging In power output from 100 to 2000 kW.

In terme of design, elze, eppearance, end performence, the new machines encompass eignificent modificatione end advancements over the seriler models. Thees first three Mod-2 prototype wind turbines cost \$13 million to build and inetall. It is setimated that they will produce electricity et a cost of less then 8 cents per kWh. If these eame mechinss were to be produced in quantities of 100 per yeer or more, the 100th wind turbine would provide power at a cost of less then 5 cents per kWh.

The Goodnos Hills machines are set up in e frianquier pattern, ranging from 480 to 915 m apart, to form e emell turbins 'ferm.' Engineers predict that (arme of 25, 50, or 100 wind furbines may be producing truly significent amounts of cost-effective slectricity by the end of the can-

The new, Mod-2 wind turbinee ere 81 m high end produce power from the rotation of their steel rotor blades, which measure 91 m from tip to tip. Each mechine'e reted power output of 2500 kW is achieved at a bleds speed of 17.5 rpm in a rated wind speed of the top of the tower of 44 km/h. (Rated wind epeed is defined as the lowest wind speed et which full power can be achieved.) The power output in relefion to the wind speed is reguleted by varying the pitch of the 13.7-m-long articulated blade fipe.

it takes 22.5 km/h of wind to start the blades rotating. and st e wind speed of 72 km/h the machine is designed to enut itself off to preclude both excess stress on the bledee and possible damage, However, in e eletionary mode the machins can withstand winds up to 200 km/h. A drive trs in, Including an improved, three-stage planetary gear box, converts the 17.5 revolutions of the blade into 1800 rpm's of the generator.

Among the major design innovetions and cosi-savings nodifications that heve been incorporated into the Mod-2 wind furbines are

Blade tip control: Unlike their predecessors, which were eathered along their full length, the speed of the Mod-2's bleds is controlled by varying the pitch of only the 13.7-mong blade tips. This has snabled designers to reduce rotor.

weight and cost. Tower: Towers for ell prior machines were of rigid trues design. These have been replaced by the more flexible,

simpler, tubular design, a modification that has permitted the use of less expensive, tactory-assembled components end an overell reduction in the amount of materiels required for tower construction.

Rotor blades: The welded steel bledes ere lastened to the hub in a straight-line tashion and ers positioned upwind of the lower Through the use of e teelering mechanism at the hub,

the blede assembly is able to till as much as 6" in response to wind loeds. This design teeture reduces loads on all of the lurbine componente and hes resulted in lower costs.-PMB 6

#### **World Earthquake Activity Increases**

The number of significent eerthquakes in the world increesed in 1980, and the earthquake death tofi was up sherply, eccording to the U.S. Geological Survey.

USGS scientiste seld there were 71 significent earthquekes recorded in the world leet yeer, compered to 56 the previous yeer and 82 in 1978. Eleven of the t 980 eerthquekee occurred in the United States, compered to five the previous yeer and four In 1978.

Significant eerthquakea are defined as those registering 8.5 or more on the Richter scale, or smeller onee that cause casuellies or considerable demage.

About 7140 earthqueke-releted deethe occurred in 1980, nearly five times as meny as in 1979, but still below the long-term average of 10,000 deeths per yeer.

Most of the deethe in 1980 occurred during or effer that quekes in Algeria and Itely. More than 3500 persons were killed in e 7.3-magnitude tremor end a 6.2-magnitude afterahock in Algeria Öctober 10, end more then 3000 persons were rsported killed in a 7.2-megnitude queke in southern Itely November 23, 88

#### Study To Examine Wind-Driven Currents

The effecte of the wind on currents elong northern Callformite will be exemined under e \$8.4 million atudy beginning April 1. The 4-yeer program, celled Coastel Ocean Dynamics Experiment (CODE), le funded by the Science Foundation. Oceanographers from five institutions will participats.

Focus of the etudy will be on the physical conditione involved in ocean movement, including water and air temperetures, and wind speed and direction. CODE'e overall objective is to identify end quentify the proceees that govern wind-driven currents over the continental shelf along a 97-km efrsich of Californie. Deta from Poini Arene to Bodega Bay will be collected by using moored instruments, floating buoys, ehipboerd observetione, lend-based etations, end electer.

CODE is a joint project of the Scrippa Institution of Oceanography, Woods Hole Oceanographic inatilution, Oregon State University, the University of New Hampshire,

and the U.S. Geological Survey.
'From a purely scientific viewpoint, we went to know the direction of the current, how last if travels, and what forces drive it, said Clinton Winani, one of the principal investigatots and an oceanographer at Scripps. From en applied point of view, the efudy is important because of the increased use of coastal water by society—for disposal of wastes, oil exploration, and commercial tishing," Winant continued. 'Knowledge of the coastal circulation will aid in

management of these resources and the monitoring of potential hezarde such as oil spille end other pollution. "If we ere euccessful in undersiending the physics which relete motive forces to the currents. Winent added, then we should have predictive models that could be applied for

ods. Winsni eeld.—BTS 🛠

conditions at similar arses enywhere in the world." As part of the program two 4-month periods of extensive sludy are plenned; one for April 1 to July 31, 1981, and enother for the sams time one year later. Ocsan circulation at the ehalf will be messured and recorded during these peri-

#### Project Alms to Improve Weather Predictions

Project Skywater, sn almospheric reesarch program sleied to begin this spring, will investigate basic precipitation probleme, including the formation of raindrops, mechaniems by which sir outside rainclouds mixee with air insida, atmoepharic procasees that lead to the birth and growth of s storm, and the origins of ice. Thase fundemanisi problams etend in the way of svalusting the potential of weather modification techniques and of predicting precipitation and severa wesihar, according to Bernerd A. Silvermen, project

As part of the project, researchers will work this eummer on the Coopersilve Convective Pracipitation Experiment (CCOPE). Beead in Miles City, Monlene, CCOPE will eludy the lifelimse of eummar clouds. The work will locue on the major natural processas thei laad to precipitation in large cloud systeme. In addition, resaerchers will investigate cloud chemietry and lightning's affect on reinfall.

About 125 scientiste from 17 universities and mora than e dozen privele resesrch groups will participale, Silverman said. Project Skywalar le funded through the Department of the Inlarior's Weter and Power Resources Service. S.

#### Geophysicists

Bemice Ackerman hee been appointed head of the new meleorology section of the Illinois Siste Water Survey. Sha hae been a professionel eclentist and e project leeder et ths Welar Survey sincs 1972.



John R. Filson has been appointed chief of the Office of Eerthqueke Studies at the U.S. Geological Survay National Center in Reston, Virginia. He succeeds Robert L. Wesson.

Paul S. Julianne, e staff member of the Department of Commerce's National Buraeu of Standards, received e bronze medel si the Eighth Annuel NBS Awerds Ceremony. The madel was ewarded for hie conlibutione to the development of theoretical descriptions of stomic collisions in intanse electromegnetic fields.

# **New Publications**

#### **New Listings**

ftems listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Geomorphology—A Systematic Analysis of Late Cenozoic Landforms, A. L. Bloom, Prentice-Hell, Englewood Olifs, Naw Jersey, xvil + 510 pp., 1978.

The Geotectonic Development of Cellifornie, Rubey, vol. 1. W. G. Emet (Ed.), Prentice-Hell, Englewood Cliffe, N.J., بلا + 708 pp., 1981, \$25.00.

Groundweier Hydrology-Second Edition, D. K. Todd, John Wliey, New York, xill + 535 pp., 1980. Illinois State Geological Survey: Its History and Activities,

Educ. Ser. 12, R. E. Bergetrom, fillinois Siete Geological Survey, Urbana, fv + 41 pp., 1980. IMS In Anterctica, Mem. Net. Inst. Polar Res. Spec. Issue 16, T. Hireeswa (Ed.), National Inetitule of Poler Research.

Tokyo, v + 144 pp., 1980. The Interpretation of Ionic Conductivity In Liquids, S. I. Smedley, Plenum, New York, xvl + 195 pp., 1980, \$25.00. An Introduction to Almospheric Physics, 2nd Ed., Int.

Geophys. Ser. Vol. 25, R. G. Flesgle, J. A. Bueinger, Acedemic, New York, xlv + 432 pp., 1980, \$29.50. An Introduction to Atmospheric Radietion, Int. Geophys. Ser. -Vol. 26, K.-N. Llou, Acedemic, New York, xll + 392 pp., 1980, \$32.50.

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Geophysicist Structural Gaologist, Albion College. A tenura track position, commencing Falt 1981, is open at the assistant professor level at Albion College a Department of Geological Sciences. The position involves teaching undergraduate laboratory courses in structural geology and geophysics and introductory tab courses or non-tab courses in sology. The Department is developing a geophyscs.geology major and has some geophysical equipment Candidales with a Ph O. or who are about to acquire a Ph O are preferred

Depending upon the applicant a background, the new stall member may have the opportunity to assist in teaching at Albion's geology field camp for additional remuneration. A 8-week summer field methods course is offered to students from many colleges and universities at the fleid camp located in the Front Bange man Boulder, Colorado Albon College is a co-educational liberal aris college to the c

lege located in southern Michigan, an hour's drive from Michigan State University. The University of Michigan and Western Michigan University. The Department has four staff members end 30 to 40 majors, it is a well-equipped department occupying a floor-and-o-half of a new acrence center.

Resume transcripts and three letters of relar-ence should be submitted to. Prof. Lawrence O. Taylar, Department of Geological Sciences, Albion College, Albion, Michigan 49224.

Directan Metacrology Division, Air Force Gaophysice Laboratory. Air Force Geophys ics Laboratory Invites applications for the position of Director of the Meteorology Division located at Hanscom Air Force Base, Massachusetts, The Division is responsible for Air Force resoarch end development in meleorology, etmospheric physics, re-mote and direct sensing technology, olimetology, and relative technologies. The division director pro-vides overall direction to an R&O program which employs over 80 people and covers e broad range of in-house and contractuel actentific investigation. A candidate should have a record of distinguished achtevament in meteorology/etmospheric physics as a rasearch sciontist and manager of a substan-tial R&O unit. This position to Air Force Senior Executive Service with a selecy renge of \$52,247 to \$57,873, subject to current \$60,112 ceiling. For an application packago, call collect: Robert Ellerin, [917) 861-2895. To be considered, applications must be estimated. must be returned by 30 April 1991.

Marine Geologisi. Oslhousie University, Department of Oceanography Invites applications for e tenure track a ssietant, or posalbly associate professcrahip The person appointed with be expen develop a etrong research programme (for which lunding opportunities exist librough NeERC Strate-elic Grants in Oceanography) end to teach end supervise graduate etudents. We particularly solicit ions from people with intereste in one or eppicanons from peops with Thiereste in one or more of; sedimentology, strettgraphy, sedimentary geochemistry and paleo-oceanography. We actively cooperate with the geology de partment and the tederal government (Bedford Institute of Oceanography). Applications with c.v.'s and names of three referees should be sent before May 1 to Prof. C. referees should be sent before May 1 to Prof. C. Seaumont, Ospartment of Ocean Beaumont, Oepartment of Oceanography, Oalhou-sia University, Haldax, Nova Scotia, B3H 4J1, Canada. Telephone numbere are 902-424-3587/3779, Telex 019-21863, Altantion: Oceanography.

Sedimeni Transport/Qaologicei Quancg-raphy, North Osrolina Stata Usivarsity. A tenura track position is available in the Copartr Marine, Earth and Almospheric Sciences at the level of assistant or associate professor. Applicante should have a thorough underotanding of sediment transport, and a general background in geological oceanography. A Ph.O. is required. The candidate will be expected to strengthen the greater to template. will be expected to strengthen the gradue le laaching and research progrems. The applicant's research interests can be theoretical, experimental, or observational, but must involve quantitative examination of venional, but must involva quantite live examine ton of marine sediment transport. Applicants should torward a resume, including ellet of courses taken; teught, end the names of at least three reterences to Dr. Charles A. Nittrouer, Chairman, Sesrch Committee, P.O. Box 5068, NC State University, Releigh, NC, 27650, Application materials should be sent by March 31, 1861.

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Division Director Atmospheric Analysis end Prediction Division (AAP) National Center for Atmospheric Research. The National Center for Atmospheric Research (NCAR) in Boulder, Colorado eseks applicatione and nominations for director of its AAP division, which concentrates on theoreticel and observetional etudies of the dynamics and thermodynamics of the lower atmosphere. AAP's four sections amphesize cilmete research, large-scale dynamics, physical mete research, large-scale dynemics, physicel oceanography, and mee ocale research. The division director is the scientific and admintetrative laeder of the division, responsible for overell

scientific productivity and excellence; ehort and fong range plenning, staffing, including affirmative The position requires e Ph.O. or equivalent in physical science; demonstrated scientific product

physical science; demonstrated eclentitic productiv-ity and breadth in ersas of AAP interest equivalent to highest level NCAR-scient湖c appointme to rignest level NCAR-scientific appointment; judg-ment about scientific quality, strategies and individ-uel competance; experience in management of ac-tivities and budgets; and ability as a scientific advo-cale.

Pisses send a letter of candidacy end s curricu-ium vitas io Or. G. William Curis, P.O. Box 6000, Boulder, Colorado 80307. (303-484-5151, Ext. 550) Applications should be received by 15 April 1981. The selected cendidate should expect to assume position by 1 September 1981 or as soon therester

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Acadie University. The Department of Gaoiogy, Acadle University, to execting a head, beginning July 1, 1981. Preference witl be given to applicants with experience and research interests in petroleum geology end related fields end/or anarray resources. Rank and aslary will be appropriate to quellifications. The successful candidate will assume teadership of an established, vigorous and growing department with five leculty members, and over 100 8.5c. and M.Sc. candidates. Responsibilities include teaching lundergraduate and gradueta levels, end aced

lanning end development in the apecialty area.

A letter of application logather with a curriculum wise and names of three referees should be sent by March 15, 1981 to Dr. Earneal E. Zinck, Dean of Science, Acadia University, Wolfvilla, N.S., 90P 1X0.

Dean of Sciences and Methamatics/Huntar Gotlega, City University of New York.
Chatanging position available July 1981, in dynamic urban inelitation. Strong doctoral research programs, extensive federal funding, major commitment to women and minorities, MeS and MARC programs, stable enrollments, major expension of lacilities in progress, attractive midtown Manhattan location. Send resums and names of three gaters. location. Send resume and names of three referitise for Oaan of Scia and Methematics, Box 447, Hunter College, 695 Park Avenue, New York, NY 10021.

Exploration Gasphysicist/University of Oklahoms. The School of Geology and Geophysics at the University of Oklahoma will hire an expedenced authorities according to the University of Oklahoma will him an expedence of authorities according to the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him an experience of the University of Oklahoma will him and the University of Oklahoma will him a province of the University of Oklahoma will him and the University of Oklahoma will him and the University of Oklahoma will him an experience of the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him and the University of Oklahoma will him a province of the University of Oklahoma will him a province of the University of Oklahoma will him and the University of Oklahoma will have been additionable will have been and the dericed exploration geophysicist to till the Frank and Getty Schuttz Professorahip, and is eeeking nominetions and explications for the position. The person must be a distinguished sciential who has made imposent contributions to exploration geometric. physics through research. Pratarence will be given to e eclentist whose apedalty is selemic proper of earth melerials and who has earned the Ph.O. The Schultz Proteasor will provide leadership and guidence in establishing a quality teaching and reeearch exploretion geophysics group. The University of Oklahome hee recently media a strong commilment to the earth sciences with the establishment of a College of Geosciencea, to be housed in a new building. The School of Geology end Geophysics will expand from its present faculty of 18 to 26 tacuity members by 1986. This will include three ecleritate in the exploration gaophysics eree, five in siructure-tectonophysics-solid earth geophysics end others in evel/grephy-patecniology, geochamistry-

petrology, and energy resources.

Applications are due Aprit 30, 1981. inquiries. nominations, and applications should be sent to John Wickhem, Oirector, School of Gaology and Geophysics, University of Oklahoms, Norman, OK

The University of Oklahoma is an equal opportu-

Geochamistry/Brittle Deformation, University of New Brunawick. The Department of Geology has a tenure track position available from July 1, 1981 at assistant professor or higher level.
The successful epplicant will be expected to teach both undergraduetee end graduatee as well as car-rying out research and auperviaing graduete alu-

Applications with the accepted in the following fields: geochemistry of ore bodies, exploration, environmental or soil geochemistry, brittle deformation, rock mechanics or eite engineer

Applicante should have a Ph.O. and prejerably, post doctoral experience. Applications including a curriculum vites end nemes of three referees should be sent to P. F. Wittems, Cheirman, Department of Geology, University of New Brunswick, Fredericton, N.S. E36 5A3.

Research Plasma Physicist. Gerkeley Scholars, Inc. has opening in D.C. area. Must be aligible for Ph.O. in plasma physics with appointing ten in and ebstracte presented on theory end nu-merical aimulation of magnetic shear effects on instability phenomena as epplied to lonospheric end magnetospherio problems. 1 year work experience in the field is required. Galary is \$24,415 per yr., 40 regume directly to Ber Scholera, Inc., P.O. 90x 983, Berkeley, California An AA/EOE.

# MICROPROBE SPECIALISTS

Sseking spacfeliele to maintain and upgrade the electron microprobe fecility at the Johnson Spacs Centar. Succeeeful applicants should have experience with the operation of an

slectron microprobe and/or SEM and e sound underatending of the theory of X-ray analysis. Exparience with computers and computer programming te highly deelrable. Familierity with geological eamplee la preferred. Time will be available to pureue individual intereste on the microprobe or other laboratories at NASA/JSC. Prefer applicants, with BS/MS degrees

Send resuma in confidence to William R. Janche at Lockheed Engineer-Ing & Managemeni Sarvices Company, Dept. C-20-EOS, 1830 NASA Road #1, Houston, Taxae 77058.

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Faculty Appointment/Colorado Stata University. The Ospariment of Earth Resources, Colorado State University Invites applications for electric lack appointment with emphasis on active research experience in remole sensing, and en interest in teaching graduate and undergraduate students beginning September 1981. The candidate is exbeginning September 1991. The caroktate is ex-pecied to have a Ph.O. degree in geology, welershed sciences or in a related flatd and is expected to deeloo and maintein a vigoroue research program with special ampheele on the application of atele-ot-thaart remote sensing techniques to the investigation of netwal resource phenomene. The candidate to expecied to teach undargreduate and graduate courses in the explication of remote sensing to nature

Tank and sellary ara open end dependent on expe-Inadione and to enotinguitary bus sone hree letters of reference and e latter descri search and teaching intereste to Or. H. O. Goyne, Op-periment of Earth Resources, Colorado Stete Uniremity, Fort Collins, Colorado 80523/(303) 491-Deadline for receipt of applications is April 15,

CSU is an EOE/AA. E.O. Office: \$14 Otudent Serv.

Ossansgraphic Mooring Tachnisian. The Merina Science Program at North Caroline Siete University (Reieigh) is expanding ite oceanographic echnical services group and to currently aceiding a echniden ismiliar with the design and deployment of deen-sea current mater mooring arrays, ea well as

Ousifications include a degree in science or engineering with some electronics background and two years field experience or an equivalent combination cation and experience. Galary commens with education and experience. Send resume and names of references to Personnal Services, North Caroline Stele University, P.O. Box 5067, Raleigh,

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Virginia Polytachnic Inatituta and State University. Igneous Petrology and Geochemis-ty/Research Associate. Origin and tectonic algorith-cance of granitic rocks. Project Involves petrography. istry, mineral chemistry, lectopic stud-

les, and field mapping. Send résumée to: O. R. Wonee, Chairman Department of Geological Sciencee Virginia Poly. tast. and St. Univ. Blacksburg. VA 24061

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Faculty Pasitions in Goology/University of Alsbams. The Oppartment of Earth Science is ssistant professor level. The Ph.O. degree is required. The selected pareon will teach one or more courses in geophysics of the undergraduate tavel, basic courses in earth science, will supervice earlic seerch projects, will develop one or note elective courses in that person's apecialty, and

will develop a reae arch program.

The Department of Earth Science consists of four tus-lims faculty and graduetae approximetely ten seniors each year. Equipment and facilities include a geochemical and sedimentel preparation equipment, student and recearch petrogrephic equipment, elson selemographic equipnent, transit and alldede, drafting tacilities, and compuler equipment. Salary is competitive and commen-

surals with experience end education.

Applicants should send a resume, three letters of reference, and a brief discussion of research interests to Michael J. Nellson, Earth Science Oepert-ment University of Alebema in Girminghem, Ekrning nam, Ala. 35294, prior to May 1, 1981. The position

wil be available September, 1981. The University of Alabame in Olimingham is en equal opportunity/effirmative action employer.

Geophysiciat North Caroline State Univer-Sity Retaigh. The Depertment of Marine, Earth and Almospherio Ociancee Invites applications for a presently available tenure track position in geophysics. Rank and salary are open, depending on qualifications and experience. A Ph.O. is required. Applied or exploration geophysics orientation ere preferable; however, ofhe

alizationa in geophysics elso will be considered. Primery responsibilities will include generating and conducting research programs as well as sacting graduate courses in geophysics. The department currently consists of 31 regular faculty members including 18 in the areas of geology and geophysics. Please send resume and names of three references to Prof. 1. J. Won. Search Constitution 1. Yon, Search Committee Cheirman, Oepartment Earth and Atmospheric Ociences North Carolina Stete University, Raisigh, NC 27850, USA. Wa hope to make a final ecision prior lo May 31, 1981. North Carolina State University le an equal portunity/sffirmalive action employer.

# Physical Oceanographer/ Geophysical Fluid Dynamioist

Arelé Associetee, e growing research tirm, located in Southern Californie, sngaged in theoretice! end empirioal physical oceanography, is offering permanent, juli-time positions. Candidelee require Ph. D. (or equivalent experience) in physical oceangraphy or geophysical tiuld dynamics. Salefee are competitive and negotieble, based on quelifications. Areté oftera a fringe benefit package of superior quality.
Qualified candidates should send resume, selary hietory, and liet of professional references to:

Personnet Administrator Areté Associates P.O. Box 350 Encino, CA 91316

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Geophysiciat. The Geology Department at the University of Southwastern Louisiana in Lalayette, Louisiana invites applications for an anticipated research/teaching opening in geophysics. Responsibilities will include one-half time in seismic investigation ol ge opressured-geothermal reservoirs of South or ge opressured-geometrinal reservoirs of south Louisiene and one-helf time leaching geophysics and supervising graduete students. The successful applicant wall be familiar with exploration estamic data acquisition, proceasing, and interpretation. The Ph.O. or Masters with experience, te required. Selan Ph.O. or Masters with experience, te required. Selary range is \$23,000 to \$35,000 per 12 month. The position is expected to be filled in the Opring of 1981 or se econ se possible thereafter.

To apply please direct a resume, three letters of stion, and any other partinent meterials to: Or. Gary L. Kinaland, Geology Oepariment, Uni-vareity of Bouthwestern Louisiene, Lelayette, LA 70504

Glaciologist/University of Weshingten. The University of Washington seeks appli-cations for a tenure track position with the individto be eppointed as assistent professor jointly in the Osparimani of Atmospheric Sciences and Geophys Ica program. Principal research interest of candidetes abould be directed toward geophysical or oil-mete releted study of enow or ice. Cendidates specializing in physical processes in enow are of particular, but not exclusive, interest. Alt applicante particular, but not exclusive, interest. Alt applicante should be committed to graduata level teaching, re-search advising, end innovative research empha-sizing edvenced expertmental methods and rigorous physical analysis. Outlies will include teaching one or two undargraduata courses par year in etmospheric sciences. The eppointment starts in Septembar 1981. A Ph.D. ts required. For additional information call C. F. Raymond (208) 543-4814. Interested per sons may send a resume and four letters of recommendetion to Professor R. T. Merriti, Geophysica Progrem AK-50, University of Weshington, Seetile,

Dead'ine for application to 31 Merch 1981.

Structurel Gaologiat. The Cepertment of Beosciences of Purdue University Invites application or a tenure track taculty position in etructural geoiogy, sterting in August 1981. Rank and eatery will be commen eurale with qualificatione. A Ph.O. is re-quired. The individual will be expected to teach undergraduate and graduate courses in etructural gool ogy end tectonics, participate in summer field courses, and pursua an active research program. Preference will be given to a candidate with en eppiled field orientation and a strong background in the quentitative analysis of tield data. The department has ective programs in petrology, geophysica, and enginearing geology end has a close working rela-tionship with the geotechnical group in civil engineer-ing and tha Laboretory for Applications of Remote Saneing. Closing dete for application is April 1, 1981. Applicante should send a resuma, the nemes, addiesses, and telephone numbers of three referens, and a briat stelement of research interests to R. H. AcCalilatar, Department of Geosciences, Purdue University, West Lalayette, tN 47907.

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Staff Soleni ists/Qcaan Margin Drilling Program. Joint Oceanographic institutions, Inc. tJOI, Inc.) has immediate openings for two stell scientists

-Field Programs Coordinator
-Ownhole Maseurements Coordinates In its Oceen Mergin Orilling (OMO) Science Pro-grems Office. Individuals (Illing each of these posi-lions will report to the OMO Chiat Scientist. They will be required to provide atall support to edvisory com mittage in their area of concern, and will be responstible for implementing programs recommended by the OMO Science Advisory Committee, including overeight of the performence of individuals or groups under contract to JOI. Both positions require a Ph.O. in an appropriate aree of earth science and eppro priate experience. The OMOP is funded for FY '81. initial appointment will be for a period of two years with the second year contingant upon the even-ebility of funds. The positions may be filled on a ro-lating bests. Salary will be competitive. Send resume, statement of interest, and the names of three referees to Thomas A. Daviss, Chiel Scientist, Ocean Margin Orilling Progrem, John Oceanographic insti-tutions, Inc., 2800 Virginie Ave, MV, Suffa 512, Washington, OC 20037. The deadline for applica-tions le February 20, 1881, or assoon thereafter as suitable candidates ere found.

Postdoctoral Research Associate. Ocean ogrephy Department of the Naval Postgraduate chool seeks recent greduate to atudy the prodynamics, through numerical ocean mo of the physical oceanographic processes solive in the vicinity of the arctio ice adge of Alasks. Problem see include the effects of the Co on the circulation and irontel formation, the dynam ated with interleaving of water masses at the ice edge, and the mechanisms hyolved in ice retreel.
Research will be performed in the context of an observationel program which has acquired data and developed insights over the course of several years.

Position to available March 1881 and is renewable annually. Belary depends upon qualifications. Send resurre and the names and addresses of these references to Feaulty Search Committee, Dept. of Oceanography, Naval Postgraduate School, Monterey, CA 83840.

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Solid Planet Geophysicist/Taxes A&M University. The Department of Geophysics at Texas A&M University is pleased to announce systlability of a junior level, lenure track tacuity position. The of a junior level, tenure stack acting possion. The department amphasizes cold earth geophysics with concentrations in tectoriophysics, geophysics and internal structure. We are seeking a talented and active researcher and teacher who will complement, strengthen; and broaden current areas of expensive programments for internal active constitutions for internal active constitutions for internal active constitutions for internal active constitutions for internal active constitutions. perties. There are excellent opportunities for inter-action and commonation with members of our deaction and optaboration with members of our de-pertment as well as those in the departments of occanography and gettiony and in the center for tectonophysics. Cualified scientists are requested to send resumes to Neville

Assistant ar Assaolais Solentist/Geasn Snginearing. Research position in sediment iransport and bottom boundary layer liows; must have background in turbulent boundary leyer tha-ory, laboratory or field boundary flow observation, llow sediment interaction, interest in biologically modified sell properties and statistics of spatial aampling are desireble. Will participate in severel estuarine and deep ocean sedimont trensport/ boundary layer studies. Expected to collaborate with geologists, biologists, physical oceanographers, and ocean engineers in these studies. Opportunities to participate in graduate education program through advising students and formal course. Recent graduate, up to five to len yeare of experience with Ph.O. in engineering, geology, physics or methematics. If interested, write to Oepartment Cheirmen, Ocean Engineering Dapertment, Box 54P, Woods Hole Oceanographic Institution. Woods Hole Ma 02543 lion, Woods Hole, MA 02543. An equal opportunity employer M/F/H.

Lunar Ceratorial Laboratary: Managar. Northrep Services, Inc. has operated and main-tained the NASA Lunar Curatorial Laboratory at the Johnson Space Center, Houston, Texas since its inception. We are now searching for a menager candidate with a Ph.O. In geology or geochemistry, evidence of administrative skills and a record of publication in the eludy of lunar aamplea and/or meteorita investigations. Position Involves the supervision of 38 technical, eclenitic and clerical emissions. ployees. Interested persons should send resume, including publications and references to W. B. Kurz. Manager of Personnel Services, Northrop Services, Inc., P.O. Box 34418, Houston, TX 77034 NSI is en equel opportunity/allirmoliva action om-

Research and Data Gystems, the Sctontilia Programmers and Programmer Analysts. Immediate openings for persons with 9.5. in adence or methend at lessi two years exparience with FORTRAN or PL1 on IBM systems. Work involves deta processing and analysis from eatolito based remote senaing systems. Experienco with time shering systeme preferred. Also have openinge for ately sciantiets with strong programming beck-ground. Send resume in confidence to Research and Oete Systems, Inc., 9420 Annepolie Road, Lenham, MO 20801. Telephone: (301) 459-0001

Hydrogaologist. An ouistending career oppotunity with excellent potentiel for advancement is currently open for a top protessional interested in applied research. Outles will include planning, deeigning and conducting broad-based groundwater resources investigations. Specialization in geochemietry including experience in hydrochemistry will be considered an asset. Oamonetrated ability to plen and exacute programe to eludy the evolution of geochemietry processes in groundwater flow systems, including the movement of pollutants through granuler or tractured rocks, is required Good writing ability is a must. Oletrici lactililes include drill rig, sophisticated geophysical logging equipment, chemistry laboratory and in-house com puter and publishing tecilities. Excellent fringe benefits peckage. Minimum entrence salary \$16.324 per ennum depanding on Iraining and experience. Minimum qualifications include M.S. in hydrogeology or geochemistry or equivalent treining elonals are encouraged to apply to: Pers South Florida Weter Managament Olstrict, P.O. Gox "V", West Pelm Geech, FL 33402.

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Goophysics Research Post: University of Cambridga, U.K. University research poet in Marine Geophysics involving teaching gradue is stu-dents, planning and carrying out research at eee and some undargraduato lecturing. Otipend £8,915-£8,945 p.e., undar reviow; live-year eppointment renowable Applications, curriculum vitae and names of three referances to Dr. P. F. Friend, Oapertmani of Eerih Ocience a, Downing Street, Cambridge, CB2 3EO, England by 27th Merch.

Postdostoral Fallowship in Experimental Patrology at UCLA. Storting epproximately ber 1, 1981, en up to 24-month appoin mant in phase equilibrium reaserch, chially hydroehould possess Ph.O. Sond letter of application and arranga for two confidential recommendations to be forwerded to: W. G. Ernet, Earth and Space ciences, University of Celifornie, Los Angoles, California 90024.

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# Vincent C. Kelley and Leon T. Silver **Graduate Fellowships**

#### THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico Invites applications for the Vincent C. Kalley and Leon T. Silver Greduals Fellowships. The tellowships will be swarded on the basis of the achoisatic record and academic promise of graduete applicants. Each tellowship will provide tor a generous living elipend of \$1,000/month for 9 to 12 months, and up to \$2,000/year for frevel and research expenses. The Caswell Silver Foundation will pay all fullion and university fees. The swards are mede on an ennual baels, but mey be renewed tor up to three years as long as the etudent maintains excellent academic standing and shows evidence of significant progress in research. Preference will be given to, but le not restricted to, applicante for the Ph.O. program.

An application for edmission to the UNM Greduate Program, trenecripts. Gredueta Record Exam resulte (verbal, meth & geology), thras lettere of reterence and a brief etalement of research goals are required for conelderellon for the fellowships. Application materiate may be obtained

Rodney C. Ewing Department of Geology Ibuquerqus, New Mexico 87131



The desdiins for applications is April 1, 1981 for the Fall sampster of 1981.

## The Caswell Silver Distinguished Professorship in Geology THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Maxico is pleased to invite nominetions or applications for the Caswell Silver Distinguished Professorihip in Geology. This endowed professorihip shall be awarded for periods of up to two years to earth actenilets of distinguished accomplishment and internetional reputation. The prolaseorehip mey be held by scientiate of ell epecialities of the earth actences in the broadeel same, end the mejor criterion for selection is thei the in-dividual be an active, productive leader in his or her field of research. The recipient must carry out a vigorous research program while in resi-dance at UNM. The recipient is expected to intereot with the faculty and students of the Department and to provide one or more seminare, in an advanced topic of his/har choics, during each academic year. The Foundation will provide unusually advantageous remuneration commensurate with the distinguished nature of the appointment. In addition, a generous allocation for travel and operating expenses (to include secre-tariel support, ensiyitos) services in department laboratories, use of field vehicles, and preparation of manuscripte) will be provided.

Applications of nominations should include a detailed resume and brief statement of major research accomplishments. Applications or nominations should be forwarded to:

Rodney C. Ewing, Chairman Deperiment of Geology University of New Maxico Albuquerque, New Mexico 87131

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New ! Geophysical Monograph 23 New! The Tectonic and Geologic Evolution of Southeast Asian Seas and Islands Dennes L. Hayes, enlare (1960) The residence of many approximational prespons in comparative research between configurations is baths United States and their counterparts. A synthesis of murine grophysical/geological in Southered Asia and related fectoric information that could serve to identify important gaps in our information base and focus attention on crucial areas for new or continuing investigations (Superior Fridance 134 pages Law peter \$25.00 This volume will serve as a togical starting

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point for many future studies of this area. VISA 2030 Florida Avenue, N.W., Washington, D.C. 20009

## **Faculty Position Economic Geology**

Tha Depertmani of Geology, University of Georgia, has a tenure track opening in economic geology. Renk end compansation ere open through the ossociote protessor levat.

Dutios includo (1) taaching courses in axploration gaochamistry (2) supervising M.S. and Ph.D. cendidates, end (3) devaloping a sirong research program with signilicent flaid commilment.

Toaching and resaerch intorests in one or more edditional faids such as ore daposit minaralogy, ratiociad light microscopy, theoretical geochamistry of ore daposits, liuid inclusion research, hydrogaochamistry, or environman tal gaochamistry ere desireble.

An epplicent should submit e delellad curriculum vitae end heve al laast ihrea tattere of recommendation eanl to F. Donald Eckalmenn, Head, Department of Geology, University of Gaorgis, Athans, Georgie 30602. The deadline for receipt of epplications is May 1.

The University of Georgia is an equal employment opportunity/affirme-

Program Manager/Meteorology. Oceanographic Services, Inc., is seeking qualified sp-plicants for the position of program manager for molecrological studies. Applicants should have an MS. or Ph.O. in mateorology or atmosph scioncos, plus orperience in the field. A broad general knowledge at sir politition, and on understanding of the air politifion, and on understanding of the air politition regulatory environment, is helpful interested persons should sand assume, references, and galaxy history to fill C. Coarks, Occanographic Services, Inc., 25 Cashian Oxye, Goleta, CA 93117.

Feculty Poeltion: Petrology Tectonice. The Oepartment at Geology at Stanfort University has an opening for e full profussor to work half-brief in the fields of potiology and tectonics. We seek someone who is interested both in teaching and in conducting research on the petrology and factories of commentor margins. Applicants are invited to send lotter of application, in rosume and the names of three references by March 31, 1981 to-School of Earth Sciences

Slanfort, CA 94305 As an equal opportunity and infilmotive action amployor, Stanford walcomes opplications from women and minorities

Upper Ocean Modeler. Two postdoctoral positions in upper-ocean modelling available in the mesoscale eli-see interaction group at the Fordra Stats University. Ph.O.'s with background in fluid State University. Ph.O. 3 with background in fluid dynamics, theoratical physical oceanography, dynamic meteorology, numerical enalysis, or physics are trivited to apply. Salery ranga \$19,000—\$21,500-yaar. Positions are supported by Offica of Naval Rasearch and may be filled et any time after and the sale of the sale April 1, 1981. Send vitoe and nomes of three references to Piclassor James O'Brion, The Florida State University, Tollahesses, FL. 32308. The University to an equal opportunity employer

Sedimentology: University of Minneso-1e. The Depertment of Geology and Geophysics invitas applications for e temporary leculty position in recent sediments starting Soptember 1961. This is likely to become a tenure track assistant professor position starting fall 1982. Opportunitias exist for interaction with the Limnological Rosesrch Canor and with active research programs in peleoecoltor and with active research programs in persoacology, peleomognetism, hydrogeology, and low-temperature geochemistry, os walf es with the St. Anthony Falls Hydraulic Leboratory, Ph.O. and strong interest in reasarch are required. Fasume, statement of rossach inforests, tronscripts, and three letters of recommendation should be sent by March

Dr. Anita L. Crews Sedimentology Search Committee Department of Geology and Geophysics University of Minnesota 108 Pillebury Hall

Minnaspolls, MN 55455 The University of Minnesota is an equal opportu-nity educator and employer and epecifically invites and encourages applications from woman and mi-

Otructural Geologiet/University of Cetifornie, Sente Borbere. Applications are invited for a tenure track appointment in atructural geology to be filled during 1981-1882, subject to availability of lunda. Rank dependent upon qualifications and ex-perience, but preference will be given to the assistan penence, but present the will be given to this account professor level. Successful candidates must have Ph.O. dagree and atrongedeire end commitment to isseen and direct MA, Ph.O., and undergraduete atudanta in both structurel and field geology. He/ahe will be expected to develop a strong research progrem and obtain outside funding for its support. Additional duties may include teaching physical geology and summer field geology.

Please send resums and syldence of teaching and research proficiency, by March 31, 1981, and arrange for early submission of four latters of recommendation to Or. Arthus G. Sylvester, Chairman, Oeperiment of Geological Sciences, University of Call-tornia, Santa Sarbara, CA 93108. (805) 981-3158. The University of Celifornia is en effirmative action/ qual opportunity employer

Soles State University. The Department of Gaology and Geophysics anticipates two lenure track positions.
Fleid-oriented Structural Geologiat with

teaching or research interest in one or more of the following: economic geology, mineralogy, engineering geology, or geohydro Geophysidst specializing in on physids spacielizing in applied esismology with a second area of interest in either geophysics

or goology.
Ph.O. is required for both positions. Sand reaums. with et least three relarances to Monta O. Wilson, Chairmen, Cepartment of Geology end Geophysics, Bolae Stata University, Solaa, Idaho \$3725. Soise State University is an affirmetive action/ opportunity employer.

Von Breun Post-Do otorel Felie wehlp in Spece Physics/University of Alebeme in Hunteville. Appointment affective September 1981 in o tenura track essistant profeseorship with reduced teaching load during the first two years. Reearch apecialty in astrophysics, plenetary science

or solar terrestrief physics. Research support avail-eble from UAH, NASA end Redstone Aresnel. Salery competitive. Recent Ph.O.e are invited to send tesums, research plans and names of four references. Applyto: Von Graun Fellowahlp Committee, Office of nic Affaira, University of Alabame in Huntsville Al 35899.

GAP

Aeronomy

0168 Tides, RAYOR and winds CORRELATIVE STUOT OF THERMOSPHERIC GRAVITT WAVES AND TROPOSPHERIC

GRAVITT WAVES AND TROPOSPHERIC VARTICITY AREA INOEK
7. T. Chia and L. R. Shatp [Specs Sciences Laboratory, The Astrospace Corpocation, El Segundo, Calif. 90245]
Sared on the occurrence icaqueecy of wave-like structures in 21, 691 individual measuremants of thermospheric density, we demonstrate that there is no significant hornispherical correlation between satellita-measured thermospheric wave-like structures and the tropospheric vorticity area today in the spech 1972-1975. However, is the northern polar zeno. [1010-900] Newsyer, is the northern polar zeno. [1010-900] Newsyer, is the northern polar zeno in 1010-900] Newsyer, is the northern polar zeno indicate of the 550 mb vorticity a rea index.

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are suggested with turbulence parameters for energy dissipation rates and varitual addy diffusion coefficients. There are maximal in winter and summer monthe, suggesting a relationship between some veves and the occation of turbulence. Wessephatic winds, tides, planetery veves, turbulence.

**Exploration Geophysics** 

G910 Saimle satheds

ADUSTIC PROPERTIES OF MURIERM ALASKA SHILVES
IN SHATION TO THE RESTORAL GEOLOGY

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veves, turbulence). Veres, turbulence). J. Gasphya. Res. Green, Paper 100166

Geophys. Res. Lett., Paper 110217

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Battelle, Pacific Northweel Laboroisrice. Applications are invited for a postdoctoral po-altion in geophysics with amphasis on middle or uppat elmospheric research at the Sattelle Observa-tory in Richiend, Washington. Stipend will be \$15,000 initially; the position offers the possibility of e permanent research position at the end of the doctorel appointment. Address inquiries to R. A. Siekea, Satiella Observatory, Battelle, Pacific Northweel Laboratories, P.O. Sox 999, Richland,

#### COURSES

Ground Water Medeling. Workshops in Ground Water Modeling ere scheduled to be held this spring at the Holcomb Research Institute, Buller University, Indianapolia, Indiana. The workshops fasture the Institute's International Clearinghouse for Ground Water Modals, which atores over 380 computer annotations of ground water models throughout the world. The workshops, co-sponsored by the National Weter Well Association, range in complexity from basice in computer model ing to adaptation of the Prickett/Longulat Model. Oates for the 1981 workshops are as follows: Part I: An Introduction to Modeling Ground-Water Flow and Transport, May 27-29; Part fit: Mathemat Ical Foundations and Computer Implementation of Ground Weter Modeling, June 1–5; Part III: Analy-ical Ground Water Modeling, May 18–22; Part IV: Adaptations of the Prickett/Lonnquiet Model, June

Instructors for Parts I and II are Dra. James Mercer and Charles Faust, GeoTrans, Inc., P.O. Box 2550, Reston, Ve., 22090, Telephone (703) 435-4400. Instructors for Parts fil end IV Include Thomas A. Prickett, Special Consultant to Camp Dresser end McKee, Inc., and William Wallon, Camp Dressar and McKee, 302 E. John St., Suite 1700, Cham-pelgn, IL, \$1820, Telaphone (217) 364-4374.

For more information on course content, contact instructors. For more information on workshop accommodationa, logistics, etc., centact Annabelle Peul or Richard Hyda, Holcomb Research Institute, Sutler University, Indienapolla, In., 46208, Tele-phone (317) 283-9555 by April 30, 1981.

# SO O O GI Spino NO TO

# **Meetings**

1

# NOAA, NASA Pian Remote Sensing Series

A sories of conteroncee on remota sansing has bean scheduled by NASA and NOAA. Thraa of the NOAA conferences will immediately tollow tha NASA meetings at Tha idanticat locations.

The NASA contarence at Purdue University will be a torum for univarsity aducators to discuss techniques, approachee, and curriculum materiels for taaching ramote sensing. The remaining NASA conterences will leature reports of data use from the Landset Earth Resourcee Salaiite. Applications of the deta for netural rasource and enviconmentel managament by slate end local govammants will be the tocus.

Al its conferences, NOAA will report on currant and future activities for operetional satelillas dasigned for remote sansing of the land.

Registration for ell NOAA conterences to being handled by Bill Span and Nancy Hoopar, Matric, Inc., 290 inlarsteta North, Suite 116, Allante, Georgia 30339 (Ialaphona: 404/ 955-1975). The dates and locations of the conferences and contacts for the NASA conferences follow.

March 9-11. Eastern Regionel Ramole Sensing Applicalion Conterence; Redisson-Ferncroft Conterenca Center, Danvars, Massachusetts; sponsor: NASA Godderd Space Flight Centar: contact Lucretia Laite, Syslams and Applied Science Corp., 6811 Kenilworth Avenue, Riverdele, Merylend 20840 (Ialephone: 800.638-0925).

Msrch 12. Oparetional Land Remota Saneing Program, Boston Confarence; Redisson-Ferncroft Conference Center, Danvers, Msssachuselts; sponsor: NOAA.

March 23. Operational Land Remote Sansing Program, Southsestern Confarenca; Msrrioti Intarsisi Allanta, Georgie; sponsor: NOAA.

March 30-April 1. Western Regionet Remote Sansing Application Conference; Holidsy tnn, Monterey, California; sponsor: NASA Ames Research Center; contact Gane Zaltself, Bendix Fiold Engineering Corp., 155-A Moffett Perk Drive, Sunnyvate, Catilornie 94086 (telephone: 415/965-6152).

April 2. Oparetional Lend Ramole Sensing Progrem, Western Conference; Holidsy Inn. Monterey, Celliornis;

April 26-April 29. Operelional Lend Ramote Sansing Program, Southwestern Conference; Sheraton Crest Hotel, Auslin, Toxae; sponsors: NOAA end Texee Netural Resources Information System.

May 16-20. Conference on Remote Sansing Education '81 (CORSE '81); Purdue University, Lsieyette, Indians; sponsor: NASA Godderd Space Flight Center; contact: Shirley M. Devis, Laboratory for Application of Remole Sensing, Purdue University, 1220 Polter Drive, West Lateyetle, Indiane 47906 (tetephone: 317/749-2052).

May 21. Operational Land Remote Sensing Program, Mid-Western Conterence; Purdue University, Lateyatte, Indiana; sponsor: NOAA.

June 29 July 1. Landsat/Geobased Information System

Symposium; Biloxi Hilton Hotal, Biloxi, Mississippi; sponsor: NASA Netional Space Technology Leboratories; conlect Marjoria Smith, NSTL/Eerth Rasources Laboretory, NSTL Stellon, Biloxi, Mississippi 39529 (talephone: 601/688-

#### Abstract Deadline Extended

The deedline for abstrects of papers for the IASPEI Genarel Assembly July 21-30 in London, Onlario (EOS, Decembar 23, p. 1237) hes baen axtendad to March 27, according to the meeting's sacond circular.

Tha second notice outlinas tha meeting's scientific program, iscilities avsilisbla, ragleiration, accommodalions, irsnsportetion, and culturel and sociel activities. Convanors ot the assambly also are listed.

Additionel information end copies of the second notice can be obtained from A. E. Beck, Dapartment of Gaophysics, Univarsity of Westam Ontario, London, Onterio N6A

#### Senior Position in Earth Science

The Earth Sciences' Oivision of the LAWRENCE BERKELEY LABORATORY has asveral comprehensive research programs involving the earth sciences. An opening exists for a person with an asiabilished notional appulation in a scientific discipling in Sorth Sciences, pasferably geomechanics or hydrogeology, to assume a position of responsibility for the scientific leadauship and direction of males. research programs such a concerned with

Outles will include faking the scienfilto intitolive and Oulies will include faking the scientitic intitative and direction and management of angoing projects, including the nuclear waste tectation steld involving more than 30 solonitists and anginests at LSt, and calloborative work with several accedents of LSt, and search algorithms. Additionally, the position involves establishment of emerging programs, expansion of respects locatilities and pursuit of new areas of investigation.

The successful condidate should have extensive experience and proven copabilities in directing and achieving programmatic goats of complex research projects invalving froms of senior scienties and angineers. A PhO in a field of the Earth Safences is preferred with significant applicable experience.

Applications will be considered no loter than April 1, 1981, interested individuols should forward two sesumes including salary history to: Employment Office, LAWRENCE BERKELEY LABORATORY, One Cyclotron Drive, Berkeley, CA 94720. An equal appartunity



### AGU CHAPMAN CONFERENCE Generation of the Oceanic Lithosphere

ompus fugli

April 6-10, 1981 Airlie House, Werrenton, Virginie

Convenors: D. C. Presnall, A. L. Hales, and F. A. Frey

Sessions planned to date:

(1) Constitution of the crust end upper mantle at spreading centers

(2) Trace elements end isotopes

Experimental petrology 4) Magmatic processes versus spreading rate, (5) Megma chamber dynamics, melt migration,

mantle flow (6) Tectonics of spreading centers

(7) Hydrothermal ectivity, metesomatism, meiamorphism Limited space remains. For information on reg-

istration and accommodations, write to AGU, Meel ings, 2000 Floride Avenue, N.W., Washington, D.C. 20009, or call Meetings, (202) 462-6903.

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1410 Chemistry of the Atmosphere
HE TWO-DIMESSIGNAL DIAGNOSTIC MODEL FOR IMPRO-SPHERIC OH: AN UNCERTAINTY ANNISTIC
M. L. Chameidas (School of Geophytical Sciences, Georgia Institute of Lathnology, Allania, GA 30332] A. Ten

3. Steln IU. 5. Geological Survey, 169 Middlefield Soad, Menio Farh, CA 900251 W. Thatcher and S. C. Castle
On 21 July 1953 rupture of the White Wolf Leuit produced the M. - 7.3 Mern County earthquahe. We used the sitesfabook zone to delight the size of the intended ally surface and applied constraints imposed by the known 1953-55 horizontal characteristics to model the measured cotalemic vertical displacements with on electic dislocation model. A curved fault trace with decreasing fault depth 137 to 10 km), slip 11 to 1 ml, and dip (75° to 30°! Iron the 1951 spiceoter at the southwart and of the fault toward the morthwart provides the fit mast consistent with the geodatic recent, the measured as isnic moment, the isuit-place solution, and the pattern of surface ruptura.

Two short relateded linus ager the 1952 spiceotect tited 4 end 17 wesdown to the corth from 5-10 years before the aerthquakes thems pressionate tited 4 end 17 wesdown to the corth from 5-10 years before the aerthquakes thems pressionate tited 4 end 17 wesdown to the corth from 5-10 years before the aerthquakes thems pressionate tited 4 end 17 wesdown to the corth from 5-10 years before the aerthquakes thems pressionate tited 4 end 17 wesdown to the sorth from 5-10 years before the aerthquakes them pressionated the post-spinds in the captural Eault from 0.1-60 years before the past to 1961 the most recent 0.65-12 My. The strained of formation was losignificant. From 1981 to 1972, uplift reathed 160 ms, macsomposed by any serface feult offset.

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Raconstruction of the watched appearacion on the Mile and the most recent 0.6-1.2 My. We estimate of coverces feuit offset.

Coverce for the most recent 0.6-1.2 My. We estimate to that in 1952. (Fre-seland), post-ealselo, geodatic, recurrence).

Coopbys. Ses., ted, Paper 8081831

M. L. Chameldas (School of Geophytical Sciences, Georgio Insifiuse of Isthnology, Allonia, G. 30312] A. Tan
iropospharic OH is belioved to piey e major role in simosphetic pholochemistry and, via its chemical inheractions, 9H uttimately may elfect the climate, statelospheric cour loves, and the pi of tain. A valeable tool for predicting the global OH abendance as a fanction of tellude end alliade is the boo-dimensional diegnostic rodol for iroposphetic OH. This model can also be applied to budget tudies of species which interact with OH, such et Dig. CO, end Ot. In eddition to laboratory-obtained limit dello, important input patemates for the model are the global distubbains of H.9. 9, 80, 60 (9H NO). CO, and CH., Mhilt sho two-dimensional diagnostic model can be tuned to yield everaged ebtelute OH conceptual on a separacemy with observations, ON concentrations is agreement with observations, the rosults are highly sensitive to encarteinties in several important variables, including the talk constants for key O(10) rections, the rete of helerogeneous removal of soluble species, and the global abundance and spetial vertability in N.O. 97. CO. and NO. J. Geophys. Res., Green, Paper JCB165

#### **Geodesy and Gravity**

1910 Crustal movements
SHISHIC AND ASLISHIC DEPORMATION ASSOCIATED WITH
THE 1033 KERN COUNTY EARTHQUARE, CALIFORNIA, AND
RELATIONSHIP TO THE QUATERMAY HISTORY OF THE S. Steln IV. S. Geological Survey, 145 Middleffeld Soed, Kenlo Ferh, CA 940251 W. Thatcher and S. C.

THE HEPACT OF REFRACTION CORRECTION ON LEVELING INTERPRETATIONS IS SOUTHERN CALIFORNIA.

IN iterage (Retional Geodetic Survey, National Ocean Survey, NOAM, Rockwills, Natyland 10537]

Exceat investigations show that the refraction correction to leveling are large hat can be adequately modeled. The corrections are proportional to the respective Afferinges and the square of the night lengthe. Changes to sight length with time have resulted in appearant crustal sovements when non-refraction corrected data were used. Applying refriction corrected data were used. Applying refriction corrected data was the call form and configuration of the senting data in southern California stgniff-cant (PM 1916) and Commentation could be and configuration of the sentence of

in reterration of prisonic slip on the Galarras Fault Havements in Galarras Fault Head Sollister, Cliffordia John 9. Langbein, 0.8. Ganlogical Survey, 385 Middie Tald Road, Menlo Tark, California 94025 Middie Road Hammer (ROM) Instrument, Constant Season of strike-siap faulting in the region obtained by the Helsovie. Four placeds of deformation that are readily identifiable in the MCDM data for the year following Saphabas 1975 on the modeled as alig on the Calarras Fault-Orespectur data tend to support this interpritation since the oreas sense and the observed spisodes of daformation space 10 he observed spisodes of daformation space 10 he

the moment for each spleade of all pose ha deteralped from the MFDH date by the lechnique of lisear programming. The recaits indicate that enclaid only 16 the dominant mechanism for atrain release since the combined moment of 1.16 a 1024 dynew for the four spleades far saceade the scene of all of the carthquahea that cocurred dacing the year. Cocepester date and geologic evidence their ero takes in conjunction with the lower bound of the moment indicates that the depth of secimals slip for some of the spleades of fault all p could extend to below the greatest depth of serthquake hypocanters for this cepton of central California. (Faull eilp, liosec programating, Goodello

Geophys. Sis., Red, Paper 100116

1050 Salations of gravity observations to INCOMINE and leastery
ISOSTAST, MACHA CHANGES AND PLATE DRIVING FORCES
ON THE EASY PACIFIC RISE
D. T. B. Lavia (Dept. of Dreenography and Geo-yhygica Program, Univ. of Machington, Smittle, Garan.

D. T. S. Levis (Bept. of Breamsgraphy and Georyhysics Program, Univ. of Washington, Saustle, 98193)

The dessity distribution within a scoling plate is calculated which incorporates temperacure and pressure affects. From this density distribution the pressure affects. From this density distribution the pressure iffects. From this density distribution the pressure itself within the plate has a horizontal gradient at shallow depths away kroz zero age and a horizontal gradient at shallow depths away kroz zero age and a horizontal gradient lowed sero age at greater depthe toused by the londing of the ocasan. leastatic equilibrium is approached if now allows the loading due to the water to depress the sociator and a the same time allows many conservation by flow at depth toward sero age. A viscosity model based on a Newtonian theology which included temperature and pressure affects has a high goodlent class to the plans separating positive and angestive pressure geadlests which would iscillate the return lies and decouple the lithmosphere from the scheenisphere. Addition of a trust to the homogeocous model does not substantially thengo those conclusions. Comparison of this model ran homogeocous model does not substantially thengo those centurelloss. Comparison of this model ran be such as a supplied by the exceptes of East Pacific Flao dots suggests that soom scaus ow not be in coapital loostatic equilibrium, implying the trist-ance of horizontal pressure geadlence loward zero age in the atthessaphere.

This model ran be unde to fit the general features of the East Pacific Blao but not the detailed gravity and topography near zero age. If the East Pacific Blao but not the detailed gravity and topography near zero age. If the send suggests that crusted and intrusion of this partiol neit that other crust, the water depths increase none rapidly used zero age and on increased positive gravity anomaly is produced over the rise sin, both of which produre a botter lit to tast Pacific Blae and many he associated with anomal

#### Geomagnetism and Paieomagnetism

2540 spatial variations attributed to sea tiour spreading NAMETIC SPECTE OF HAGHSHITESATION OF OCCUMENCE

MANETUL EFFECTE OF MACHEMITERATION OF OCEANIC TRUST

N. Préwot U.S. Geological Survey, Ms SS, tas Middlefield Nod. Fenio Park, Caiffornia 44025; d. tecalile and S. Mankinen

Magnacic wiferts of magnamitimation are strongly dependent on the grain size of the originally movidized citeromagnetits. Naghesicization of single-domain titenomagnetits remains in a decrease in conservity, on increase in susceptibility, and a large decrease in 9 ratio. Meghantimation of mulcidomain titenomagnetits remains in an increase in coerretty; decrease in our strongle-domain titenomagnetits, which is che main carrier of remanasca in mulmanina entrusive cocks, in invantigated by comparing the magnatic properties of the FAMOUS and the Leg 37 pillow healts. The FAMOUS rooks are sized of widled lie 0.381; possibly as a result of mouse high-temperature magnamic leation during cocking of the magna. Low-temperature magnamic lastic during cocking of the augus. Low-temperature magnamic list of such rooks does not result in appreciable changes of coerretty and susceptibility alchough the 0 racio does decrease and CRM sames to be coquiced.

J. Gomphys. Eas., Red. Fapar 180113

J. Gomphys. Res., Red. Paper 180113

2560 Time restation, paleomagnetism PALEONACHEFISM AND AGE OF MAPIC PLOTONE, VECHITA PALEDRAMENTER AND AGE OF MAPIC PLOTOMB, VECHITA MORRATAINS, OKLAMMA W. Roggenthen (South Dakota School of Mines and Tachnology, Repla City, 80 57701] J. Flather, C. Hapoleons, and A. Flather
A pathomagnatic reconsisement (43 asspine of the Baggady Mountain Cabbro Group, comprised of a tee magney Mountain Cabbro Group, comprised of layared complar of morthentian, amorphatic gabbron, and massive gabbro, shown: [t] etable remnsed asgestisation and [f] completant disce-tions which differ eigniticently from those of the massive Cambelse Wichita Granils Group, with the nearby Cauhcias Wichita Granzis ucoup, with arception of one site oner the grantis tomest. These results august a Frenancia op in the gabro group. The difference in pole positions between the graniite and asfic groups demon-bers the platonic apisodes respeciable strates that the platoule appendes transmenths for the mails and granits esgame are stpail; cantly esparated to time. Models of formation the Michica assessment should be stored to expect for the difference in the between the

ecroset for the difference is time between the mails and ellicit plutoates, (aulatogas, Wichite Houstetes, Fresabrien, pelaceagnetism).

Geophys. See, tatt., Paper 60LiA01 2560 Time variations, pilosespectics PALBONACHETISM AND TECTONIC EVOLUTION OF THE PAT-APEICAN DAMARA BELT, SOUTHERN AFRICA H, NEWILLIAMS (Dut. of Geofficies, Standard University, Itaniard, CA 94305) A, Krönet Felconagnetic romules are reported from the Nonth, Ocavi and Ruiden Groups of the Danare Supergroup, a late Pencembrian shelf sequence on the smathern margin of the Grape Lates in Nami-bia. These sequestations were isolated in the Nonth group ambita. Le order of decreasing blooding temperature they are: Myl in-6 situm, 12878, 9-1377, 09-1377, 092 (0-7 mites, 17978, 9-1377, 09-1377), 092 (0-7 mites, 17978, 9-1377, 09-1377), 09-13 manufes of all increasing section sequences. The State of the Stat Paleonagnetic results are reported from Nowith, Otavi and Muiden Oroupa of the Damers

of the lither-chore undernorth the Darara belt, tollowed by delamination of the web-restal lither-sphere. Not authorophoric, naterial rises to take the place of the detached and mishing lither-chores. and place of the deficient and allowing frame-aphorts baros, inducting subduction and internstacting of continental crant. The much thickened courtin-ontal start to partially subtred at depth, introded by some and post-otogonic manuface and itality up-tificed and eroded to the present level of exponents. The chofel is compactable with plate tectories in that the development of the Darura belt can be breadly compact with evident presents. broadly expared with twicen purginal mean, with the exception that stretching of the lithogenero was not induced by

2599 Coneral or attachlantous ANOMALOUS MACHETIZATIONS 18 3.4 S.Y. OLD DARBARTON MOUNTAIN LAND SAMPLES Stanlay H. Cloowki (MASA Headquarteta, SI-1, Ash Instan. D.C. 2053A1

Stanlay II. Cloweki (1885 Meadquarters, \$1-5. Mashington, D.C., 2053b)

Yho tethn of natural remanence (1889) to esturation remanence (1881) is found to be exceedingly high low a mapber of basaltic to ultramilic samples from the 3.4 billion year old Batherron Mannain Land greenatione belt, South Africa. Afthough receiventional galeointensity methods indicate paleofiteled of several constitute scale clearly show the MRN in those supples to be unlike thornal remanence (1881). It seems reast probabile that the observed MRN is a chemical remanence (1684) voluted to the greenachial retainerships the result of internal remarked, and that the intenne magnetizations are perhaps the result of internally generated, enther than excernal fields. The probability that the internal mapher is unrelated in the secongth of the external field suggests cantion in the interpretation of paleointensity remaits from extraterrestrial materials. (Paleointensity Precambilan) toophys. Ses. lett., Paper 80:1771

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#### Hydrology

1125 Glaciningy TIDAL FLEXUEZ OF JAKUSSHAVNK GLACISS, WEST GREENLAND GMEMIAMO
Craig S. Ilnpio (Geophysical and Polac Research
Craig S. Ilnpio (Geophysical and Polac Research
Centat. Malworsity of Wisconsin, Maditon,
Misconsin, SiMol, Terence J. Kughen (Department of Geological Sciences, Mulwrait, of
Maina, Orono, Maine Géoph. Ponaid C. Kolimeyer
(Department of Physical Sciences, Maintt States
Coast Guard Acadeau, New London,
Connecticut Re 1201

Connecticut 0e)201
Ishobshavas Electer, a libering outlet placier on the West Greenland coast, was surveyed during July 1976. The vertical displacement of terpetations of profiles perpendicular to the lipord wall bounding the morth margin of the glacier were analyzed to determine the effect of flowers caused by ildel oscillations wishing the force.

of flavore caused by iidal oscillations within the flord.

An analysis based on the assumption that wertical displacements of the glariet reflected pure electic bending visited the conclusion that the effective thickness of the ice ii.e. the thickness which recalled unaffacted in any lace and based cracking and which behaved as a continuor was which of the injection from the calving front, and will now, and incoming cast in the calving front, and will now, and incoming cast in the calving front. alving front.

An analysts based on the nors restigric

An analysts based on the care resiliate assumption that observed benjing reflected slastic and viscoplastic deformation visided the conclusion that the average ellective this mose of the ice was 10 f.2 m in Aux of the estimated 800 m coral thickpoint 2.0 to ice. the calving from, and hold of a men of the calving from. A constitutive relationship appropriate for hard glide during from the calving from the calving from the calving from the calving the constitutive relationship appropriate for hard glide during from the calving from the c

glecters.1 J. Geoghys. Gos., Red. Paper |80|10

3130 Gradedwater FLOW IN AGDIFFERS SITE CLAS LAWINAR-11 STACT

FLOW IN ACCURAGES SITE (TAN LAWINAE-1) ELACT SOLUTIONS

O.D.L.Strack (Ospactment of Civil and Sineral Engineering, University of Minnascha, ISA)

Stack spletions are determined for two cases of two-disensional flow in agatiers with horizontal impervious luminae. The flow occurs in the vertical plans and the thichests of the luminae is actical plans and the thichests of the luminae is acticated. The first problem is one of confined light in the holifer terminal problem. lies in an againer spaces with an infinite limits with a slot. The second one to a case of uncon-itsed flow to an equifur space with a sent-laffaite limits. The solutions are deterstood by the use of standard conformal against against the use of standard conforms and detertined by the use of standard conforms impring procedures, and are compared with approximate solutions ob-tained by the use of the technique presented the gast 1. The agreement to good, provided that she catio of aguifar length to aquifor thichang to unificiently large. Ideas solutions, conformat

Water Pasour. Pea., Papar BDW1840

3f 50 Precipitation

3f:30 Pracipitation
AGIO RAW: SOME PRELEMEART RESULTS FROM GLORAL
DATA ARALTSIS
S. Sequelca (National Oceanic and Ascosphecic
Administration, Aic Emsources Laboratories,
Bliver Spring, Haryland 19940)
Pracipitation data from WHO (Morid Exteoriogical
Organization) stations suggest that away remote
macis continents, could betwee predisposed to
solid csio if there is a deficiency of som-macina
csiciam relative to non-arrine suifata. The
regional stations show greater complication
the baseline stations to their precipitation
chemistry. The averall raroles of that analysis
suggest that nos sil ion-arrine suifate and natrace to precipitation could be present as acid.
Ocephys. Res. Lett., Paper 120011

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